Interagency Task Force Meeting

May 31, 2018, 9:00 a.m. to 12:00 p.m.

Missouri Water Resources Plan

Welcome!

Carol Comer

Director

Missouri Department of Natural Resources

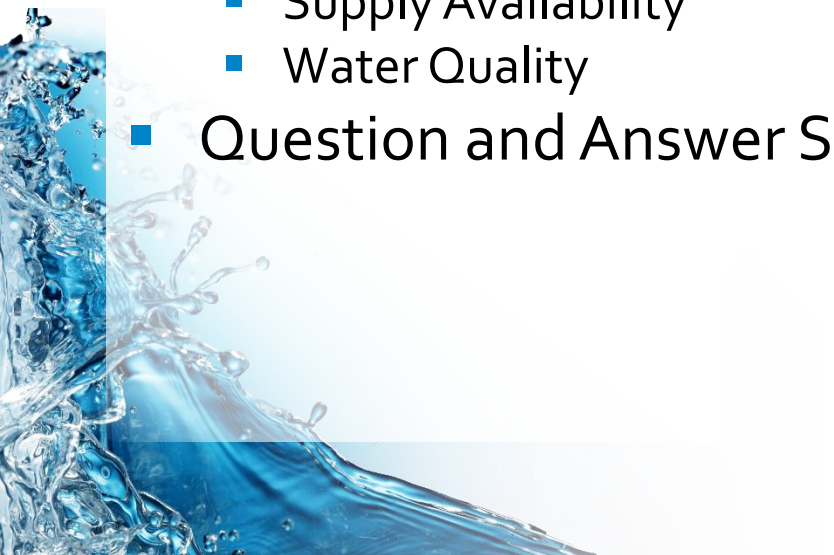
Jennifer Hoggatt

Director

Water Resources Center

Agenda

- Welcome & Introductions
- Plan Responsibility & Vision
- Scenario Planning Overview and Performance Measures
- Plan & Technical Workgroup Updates
  - Demand Forecasting
    - Consumptive
    - Agriculture
    - Non-consumptive
  - Supply Availability
  - Water Quality
- Question and Answer Session



MISSOURI WATER RESOURCES PLAN

Introductions

Missouri Water Resources Plan - Responsibility & Vision

Missouri Water Resources Plan

- Statutory Responsibility (640.415 RSMo):

  "The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs."

MISSOURI WATER RESOURCES PLAN

Project Vision

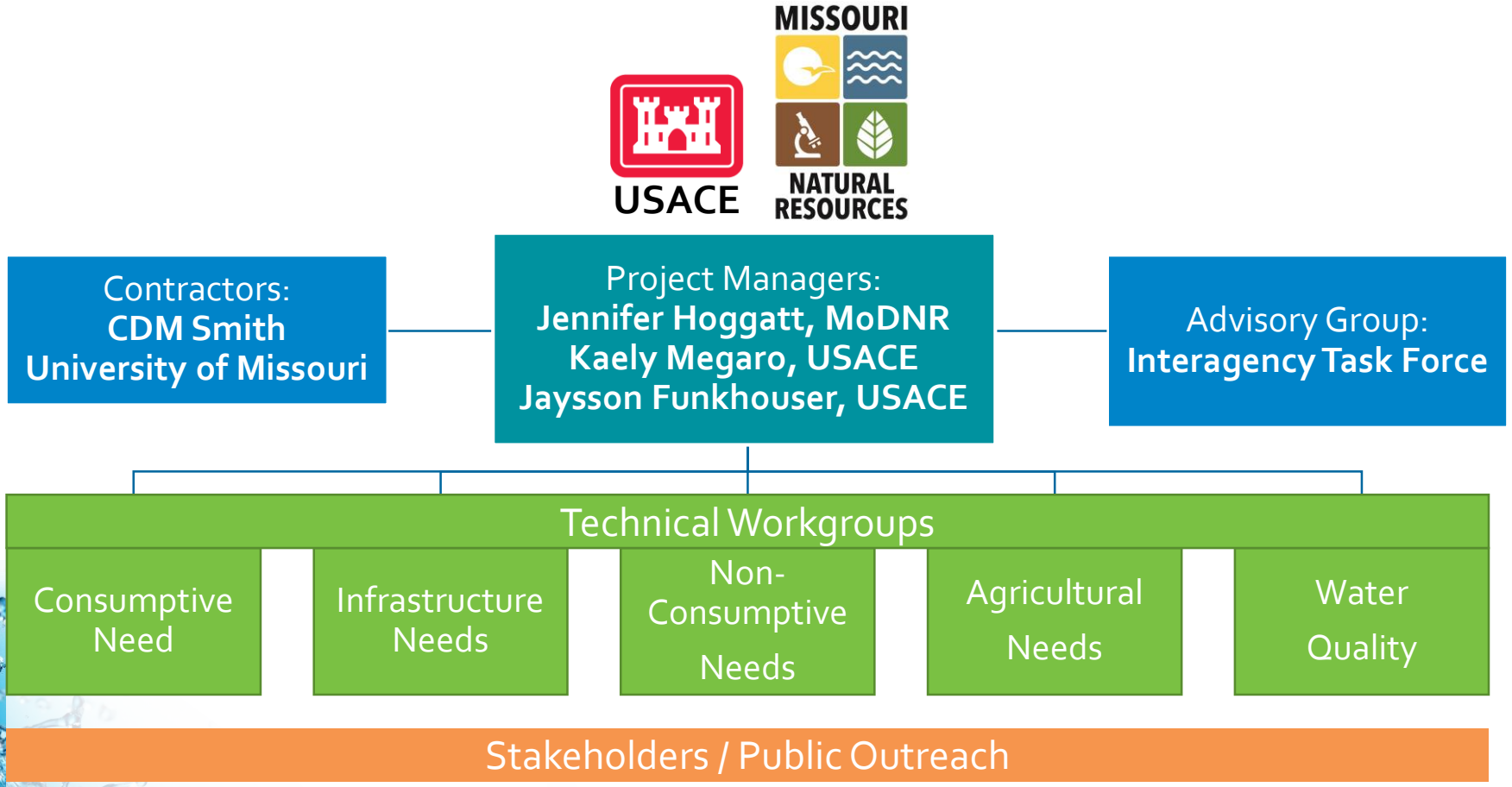
The Missouri Water Resources Plan is a long range, comprehensive strategy to:

- Provide an understanding of water resource needs
- Ensure the quantity of water resources meet future water demands
  - Identify future water supply shortfalls
  - Explore options to address water needs

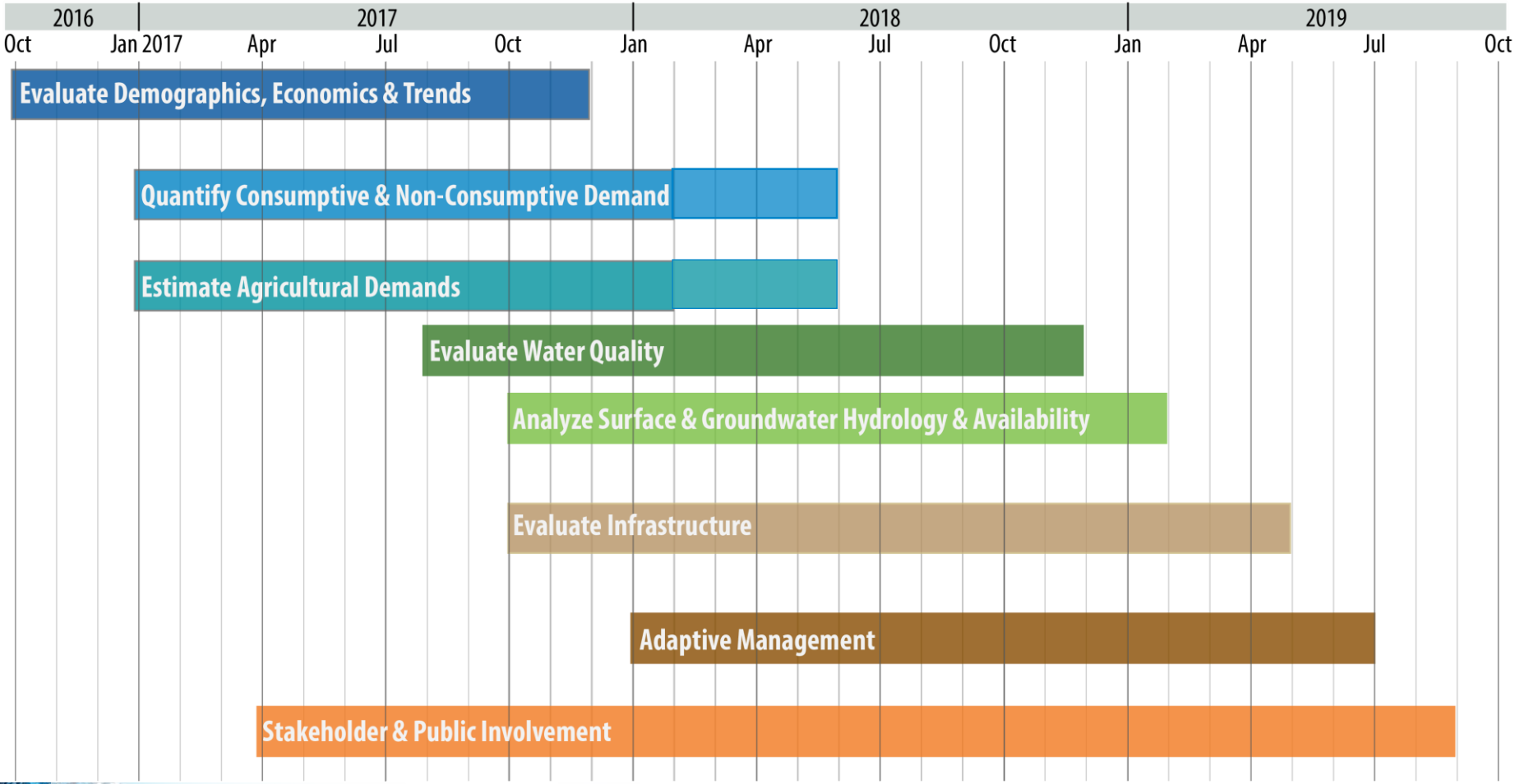
MISSOURI WATER RESOURCES PLAN

Missouri Water Resources Plan - Team & Schedule

Missouri Water Resources Plan Organization Chart



Missouri Water Resources Plan Schedule



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Technical Workgroup Meetings

Previous Meetings:

- **November 14-16, 2017**
- **February 6-8, 2018**
- **May 15 & 16, 2018**

Upcoming Meetings:

- **August 28, 2018**
- **November 28, 2018**

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Scenario Planning Overview

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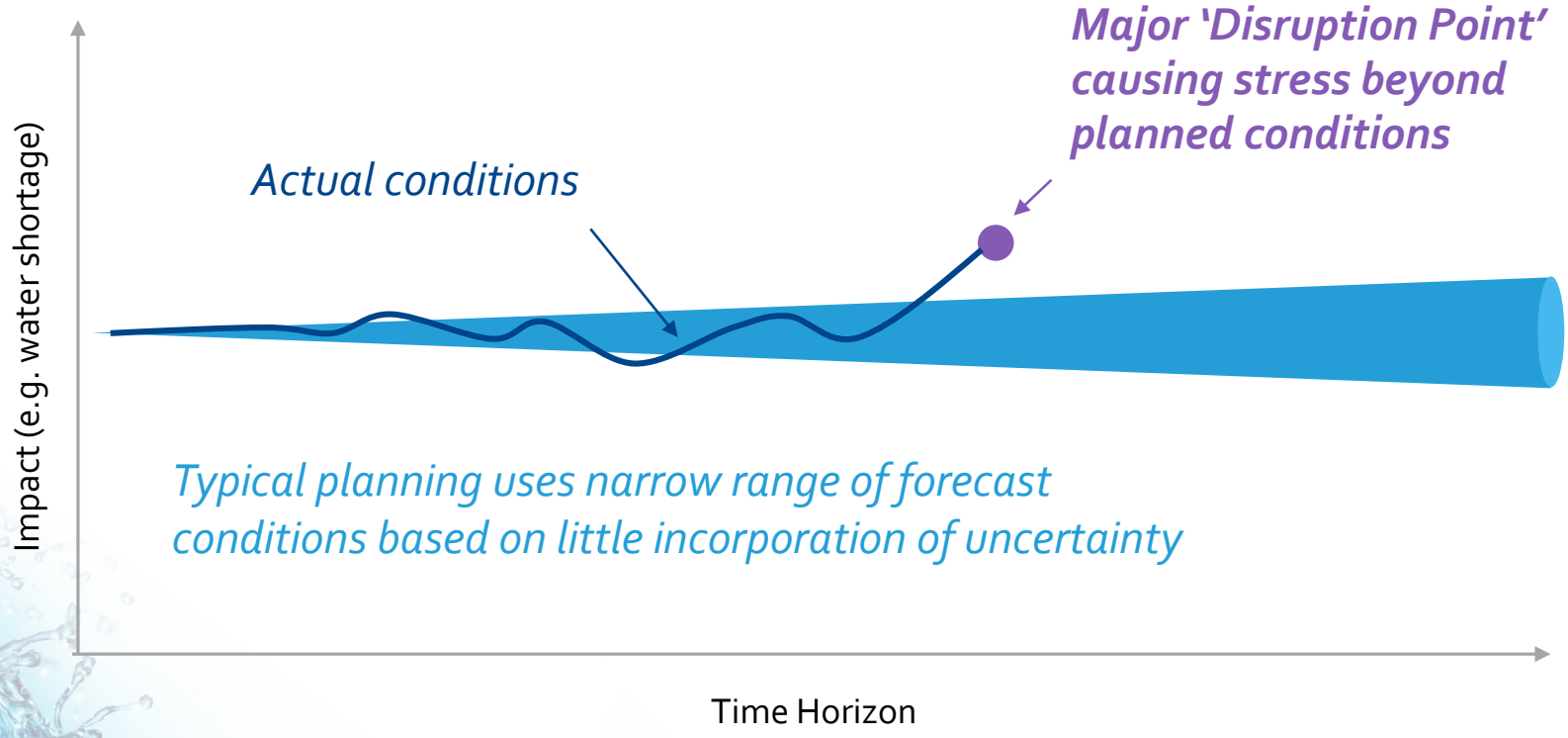
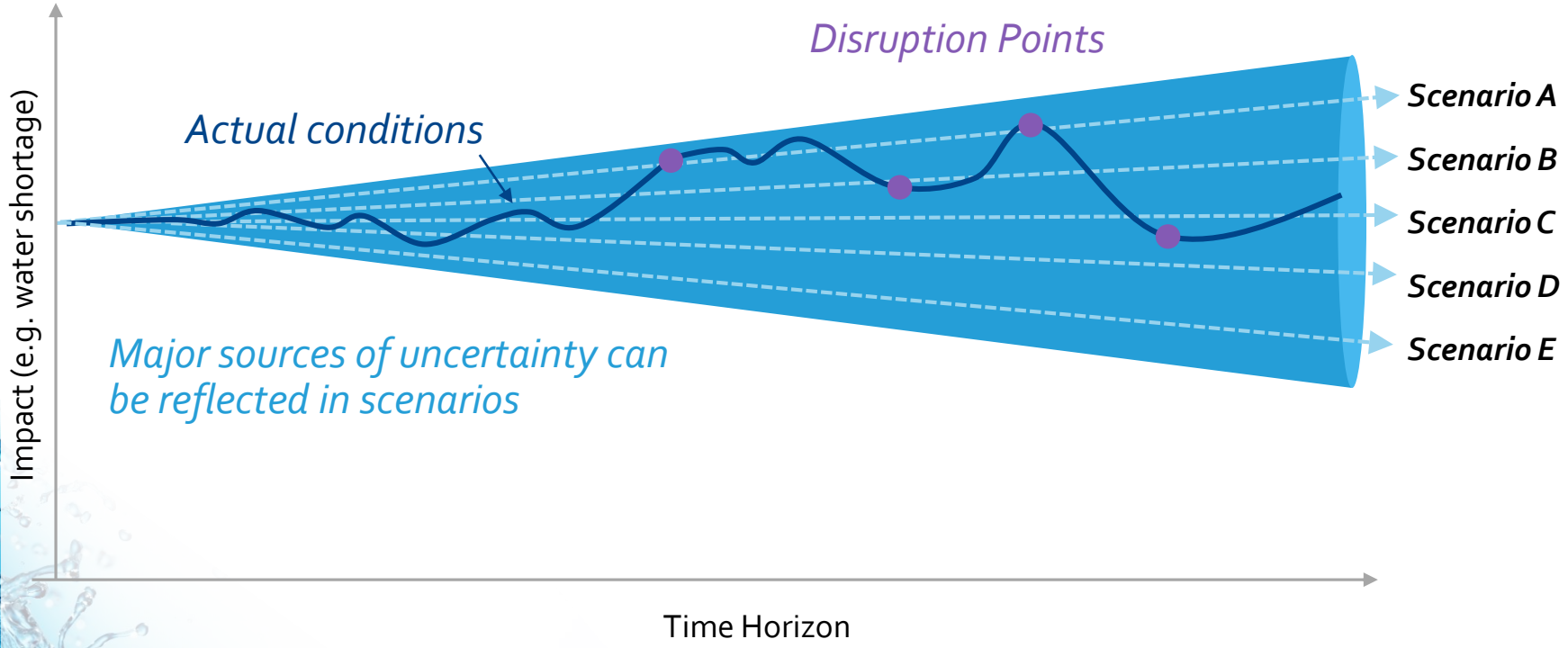
Why Scenario Planning?

- Water managers have to plan for the future
- One thing that is certain is that the future is uncertain
- Given the time and expense to plan for programs and critical infrastructure, it is essential to account for uncertainty
- Scenario planning is a structured way to account and plan for uncertainty

Typical Water Planning Paradigm

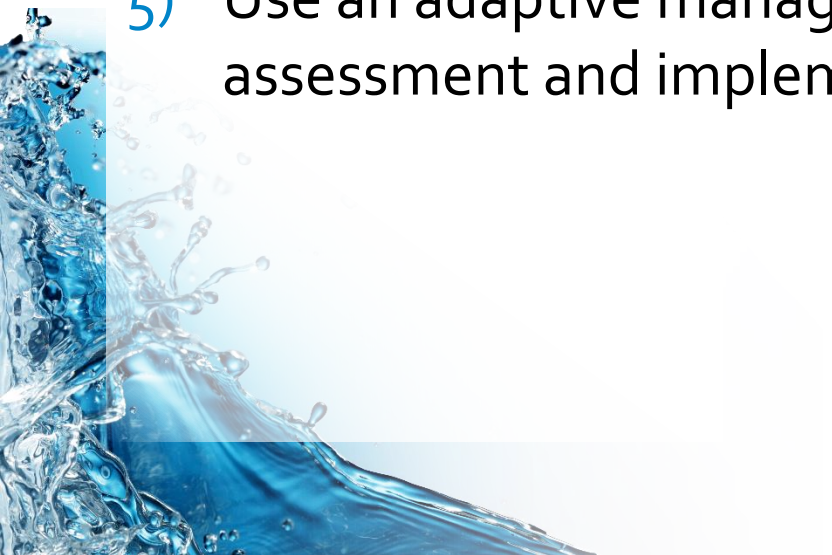


Why Scenario Planning?



Steps in Scenario Planning

1) Identify major uncertainties that can impact the future
2) Select most important uncertainties as "drivers" of scenarios
3) Develop scenario narratives from combinations of drivers that represent a plausible range of future conditions
4) Measure impacts of scenarios and assess strategies to address impacts
5) Use an adaptive management framework for continuous re-assessment and implementation of strategies



Example of Scenario Narratives

	Uncertainty Drivers				
Scenario Name	**Population Growth**	**Development Density**	**Future Climate**	**Social Behaviors**	**Regulatory Framework**
Business-as-Usual	Medium	Medium	Historical variability	Current sustainability attitudes	Current
Weak Economy	Low	Low	Warmer/wetter	Sustainability attitudes erode	Less stringent
Hot Growth	High	Medium	Hot/dry	Current sustainability attitudes	More stringent
Adaptive Innovation	High	High	Hot/dry	More favorable sustainability attitudes	Adaptive

Adaptive Management

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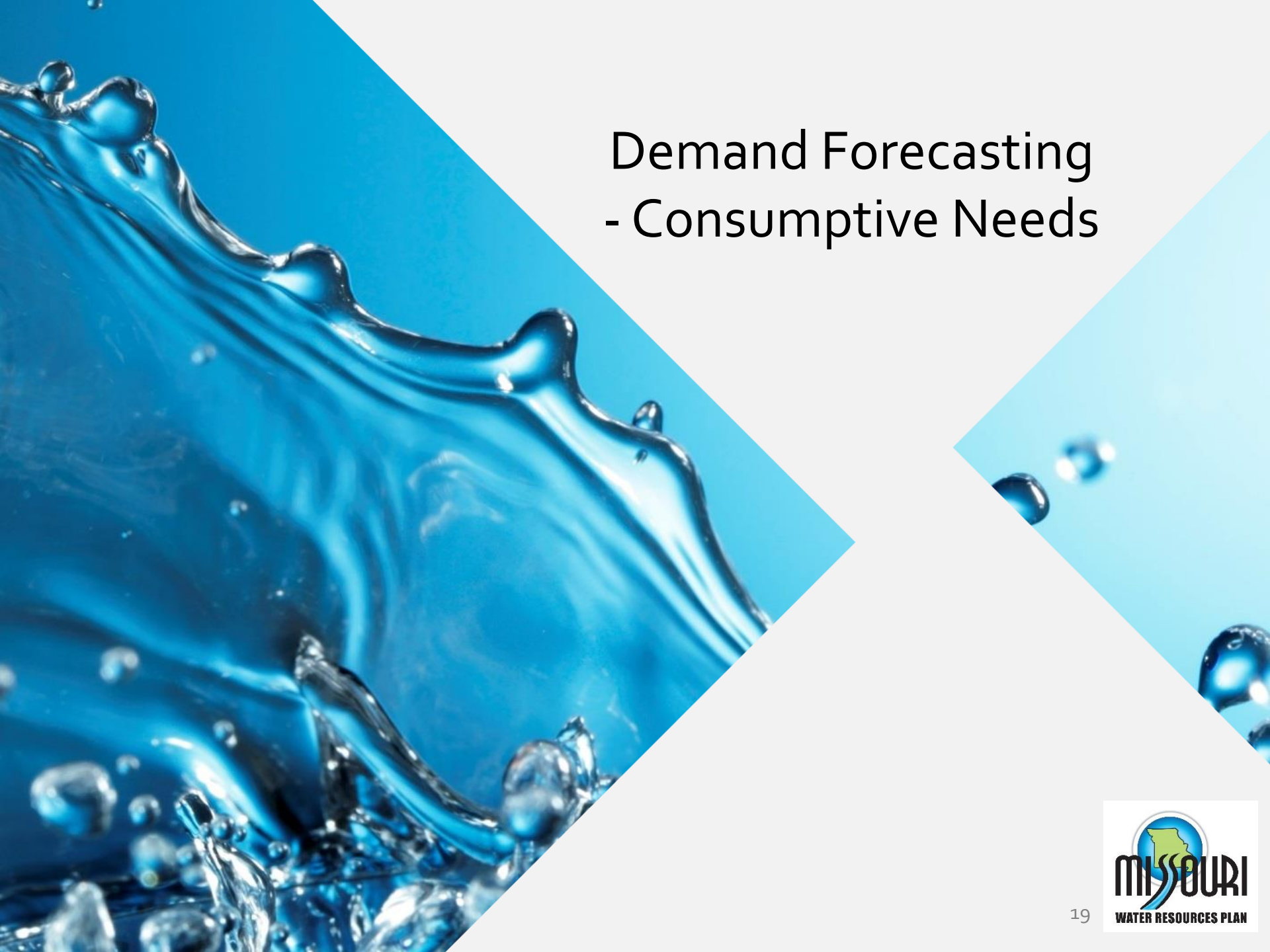

Demand Forecasting - Consumptive Needs

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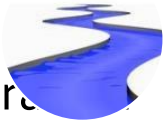
ALL WATER DEMAND SECTORS

Consumptive Demand Quantified

- Major water systems
- Self-supplied nonresidential
- Self-supplied domestic and minor systems
- Thermoelectric power generation (small portion consumed)
- Livestock
- Agriculture irrigation

Consumptive demand refers to water that is withdrawn from the source and consumed in a way that makes its use all or partially unavailable for other purposes or uses.

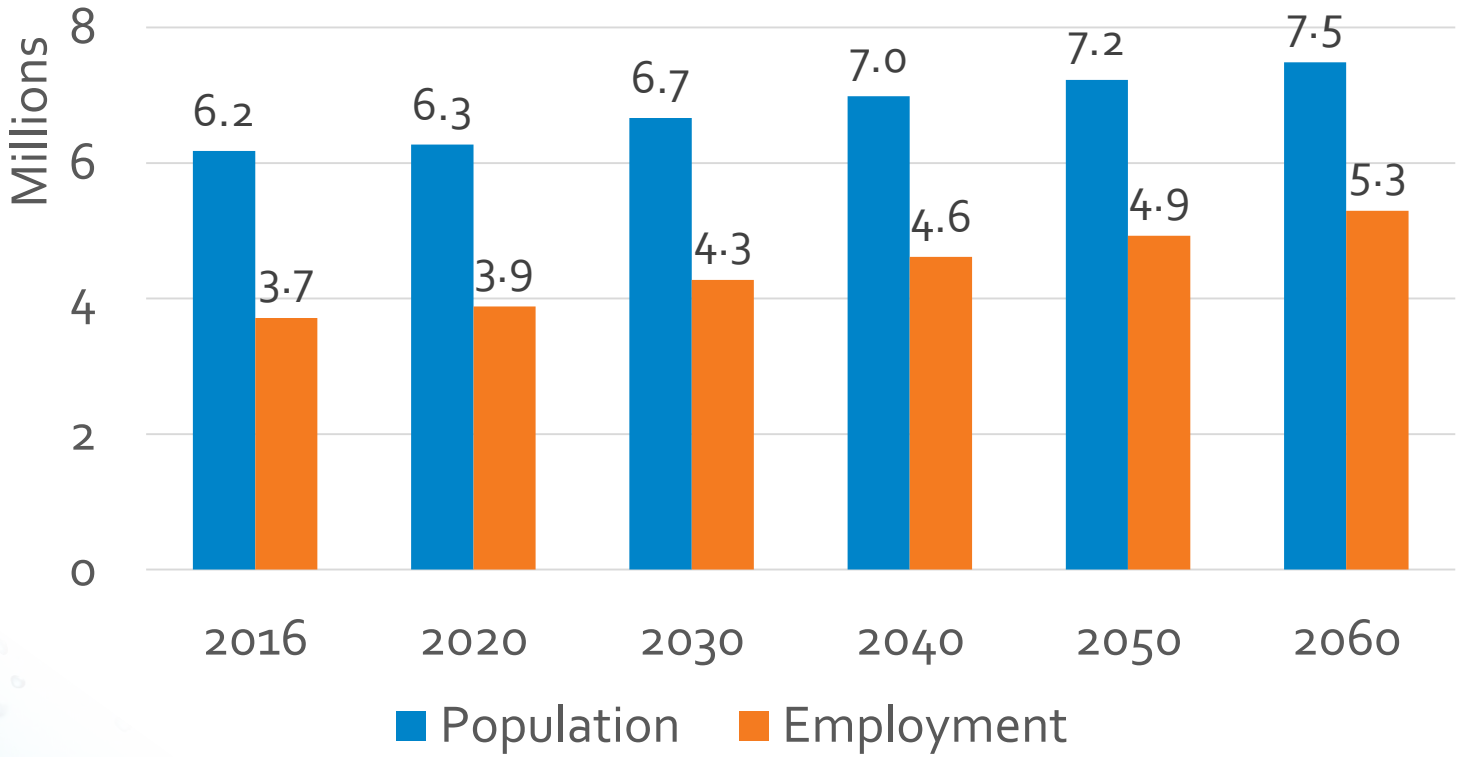
Non-Consumptive Demand Characterized



- Hydroelectric power gener
- Commercial navigation
- Aquaculture and hatcheries
- Wetlands
- Water-based outdoor recreation

Non-consumptive demand refers to uses that rely on water in the streams, rivers and lakes for everyday activities. The water is not consumed and is available for other uses.

Growth in Population and Employment Forecast to 2060 – State Totals



Source: Woods & Poole 2017 Complete Economic and Demographic Data Source

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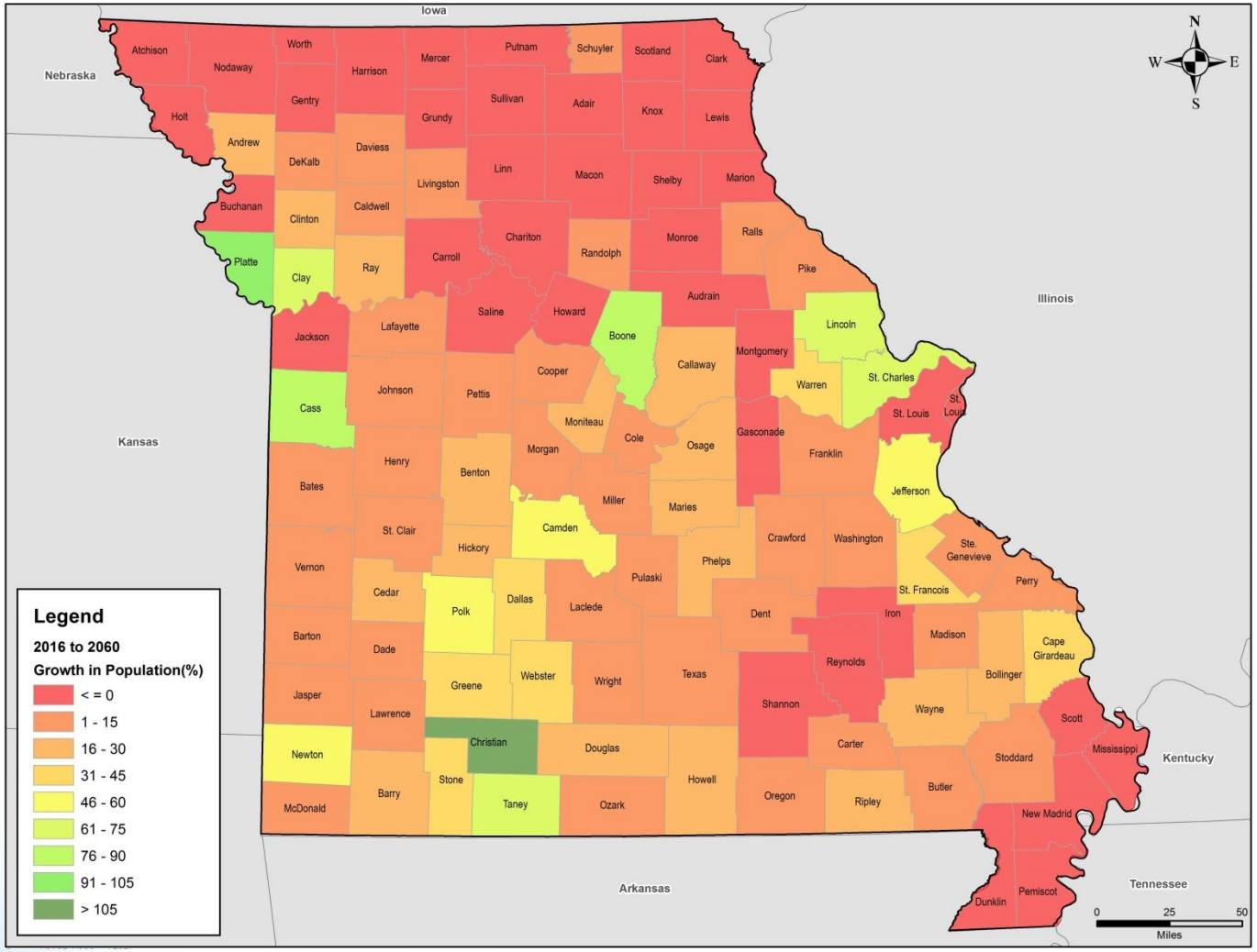
Growth in Population (2016 to 2060) by County



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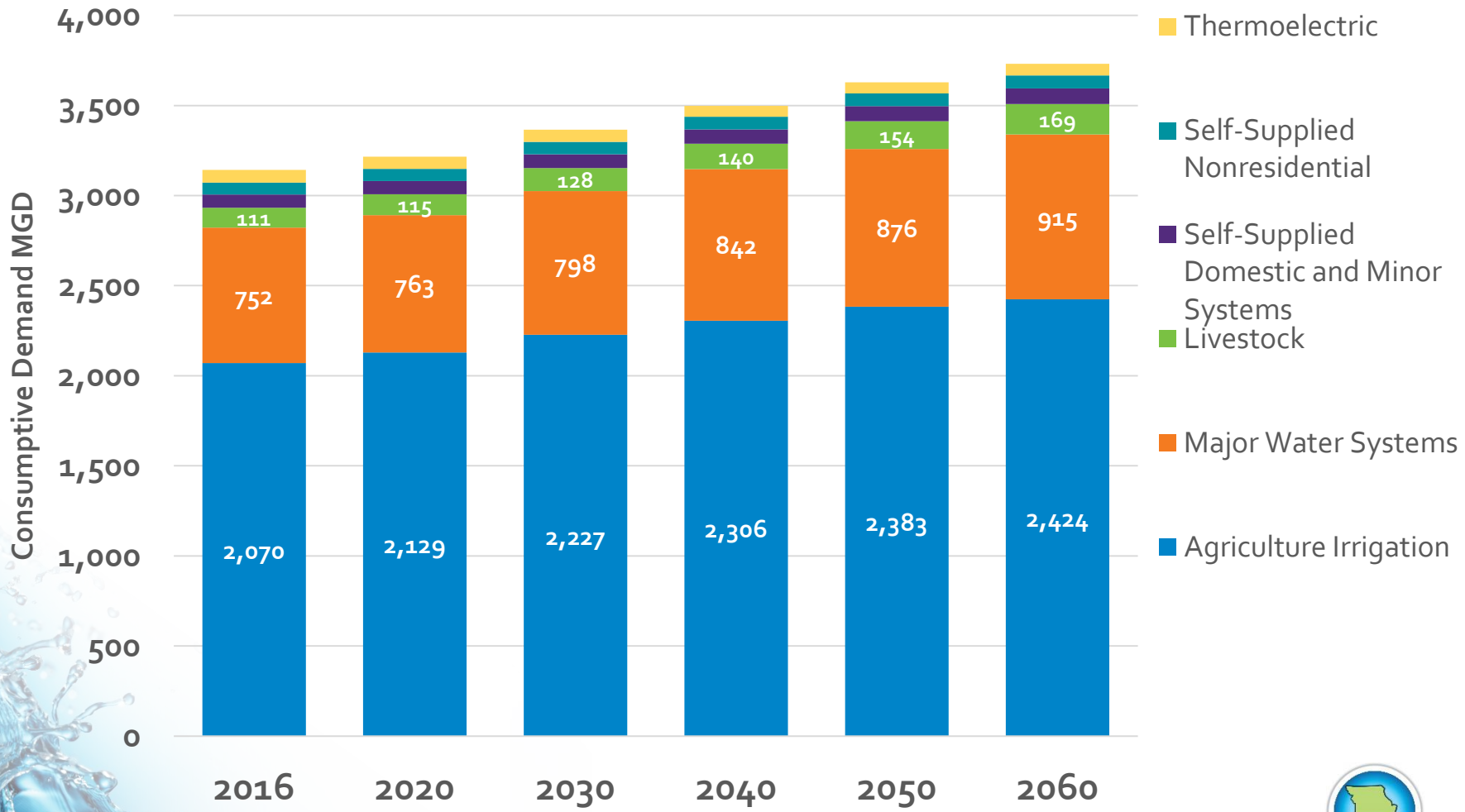
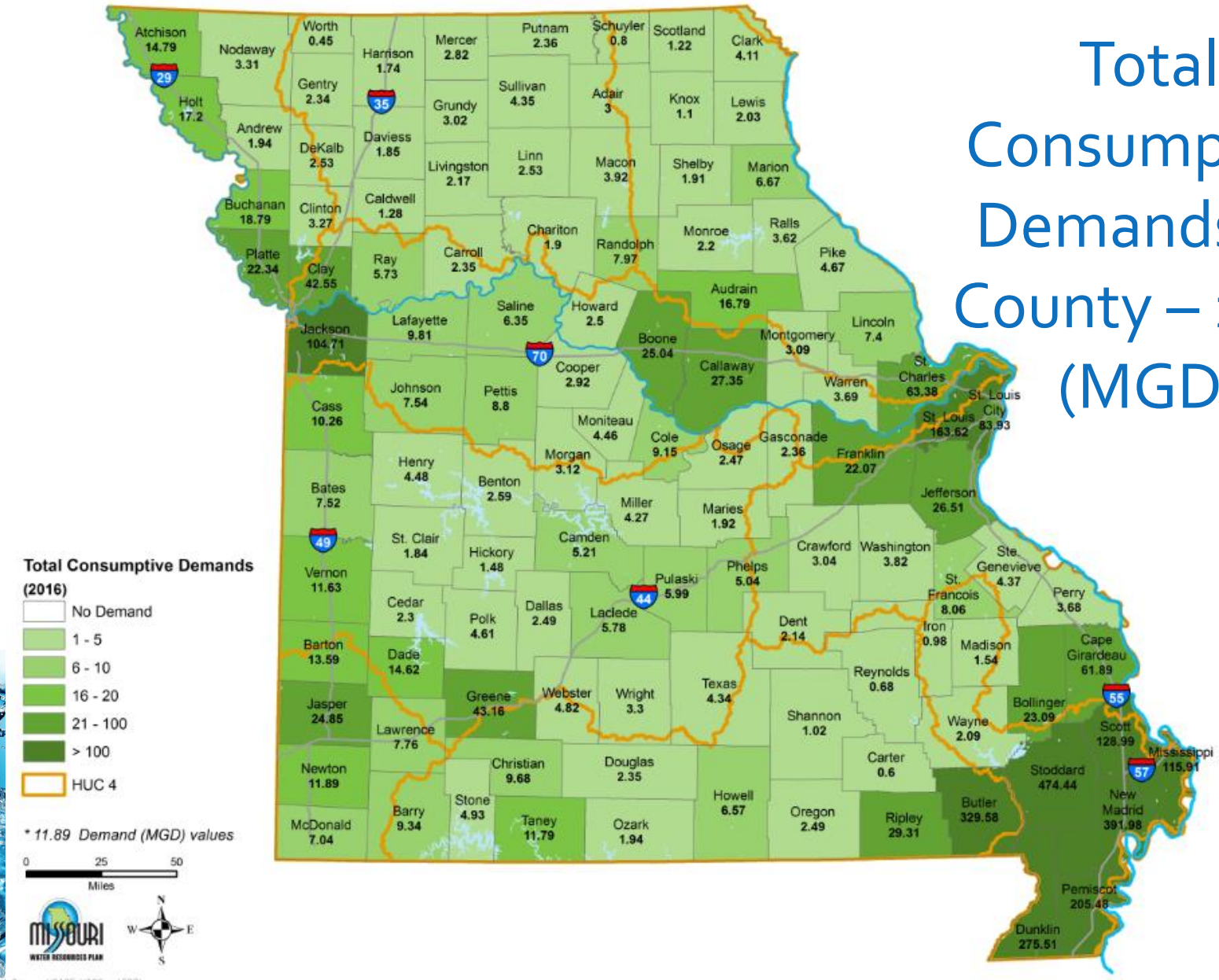
Statewide Consumptive Demand Forecast



MISSOURI WATER RESOURCES PLAN

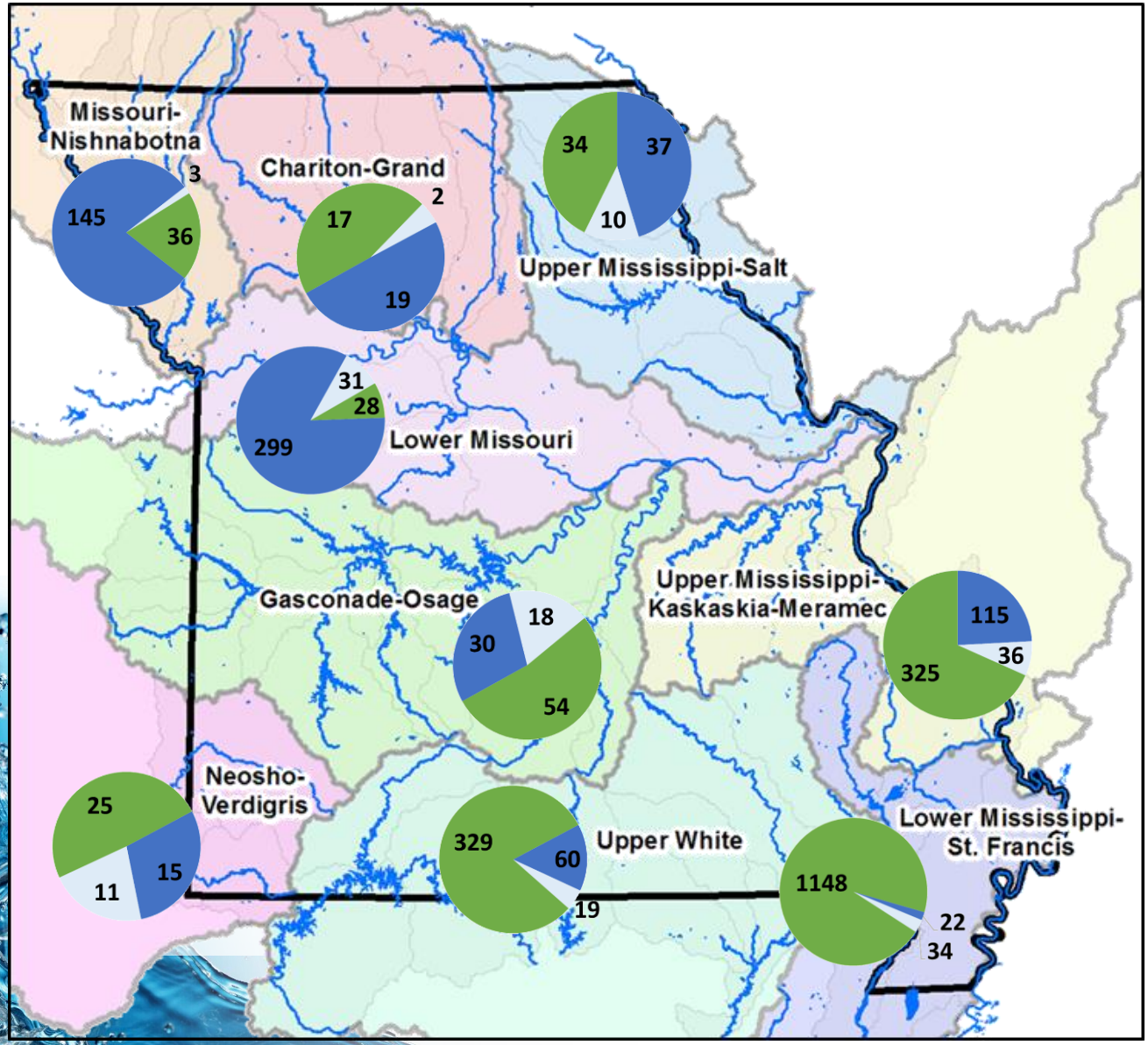
Total Consumptive Demands by County – 2016 (MGD)



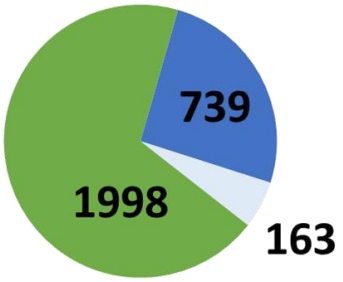
Sources: USACE, USGS and ESRI

MISSOURI WATER RESOURCES PLAN

Current Total Consumptive Water Demands (MGD) by Sector



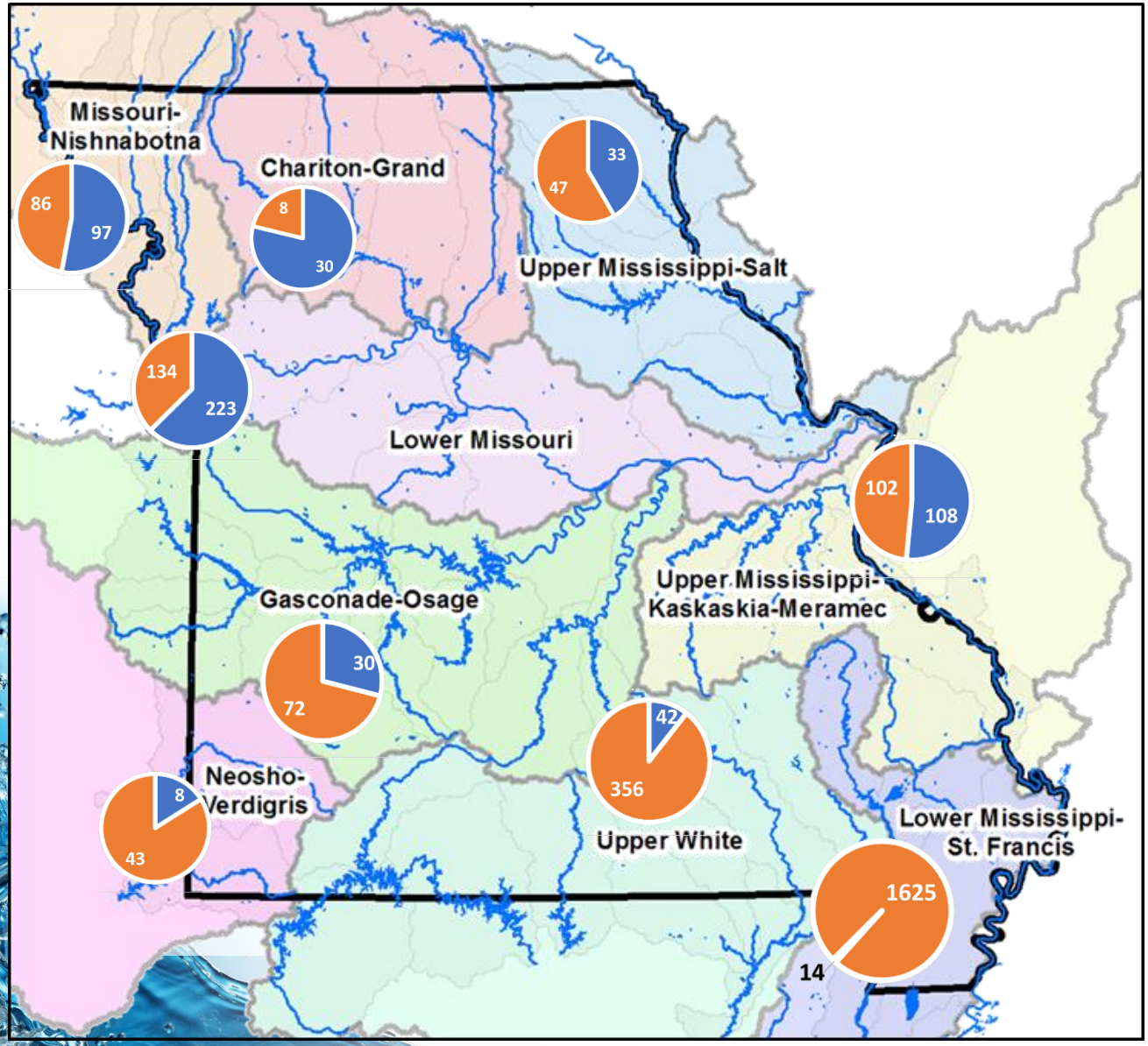
State Total

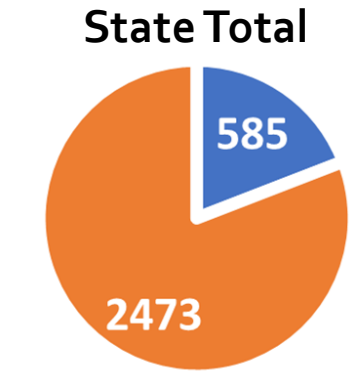


- Agriculture
- Major Water Systems
- Self-Supplied Non-Residential, Domestic, and Minor Systems

MISSOURI WATER RESOURCES PLAN

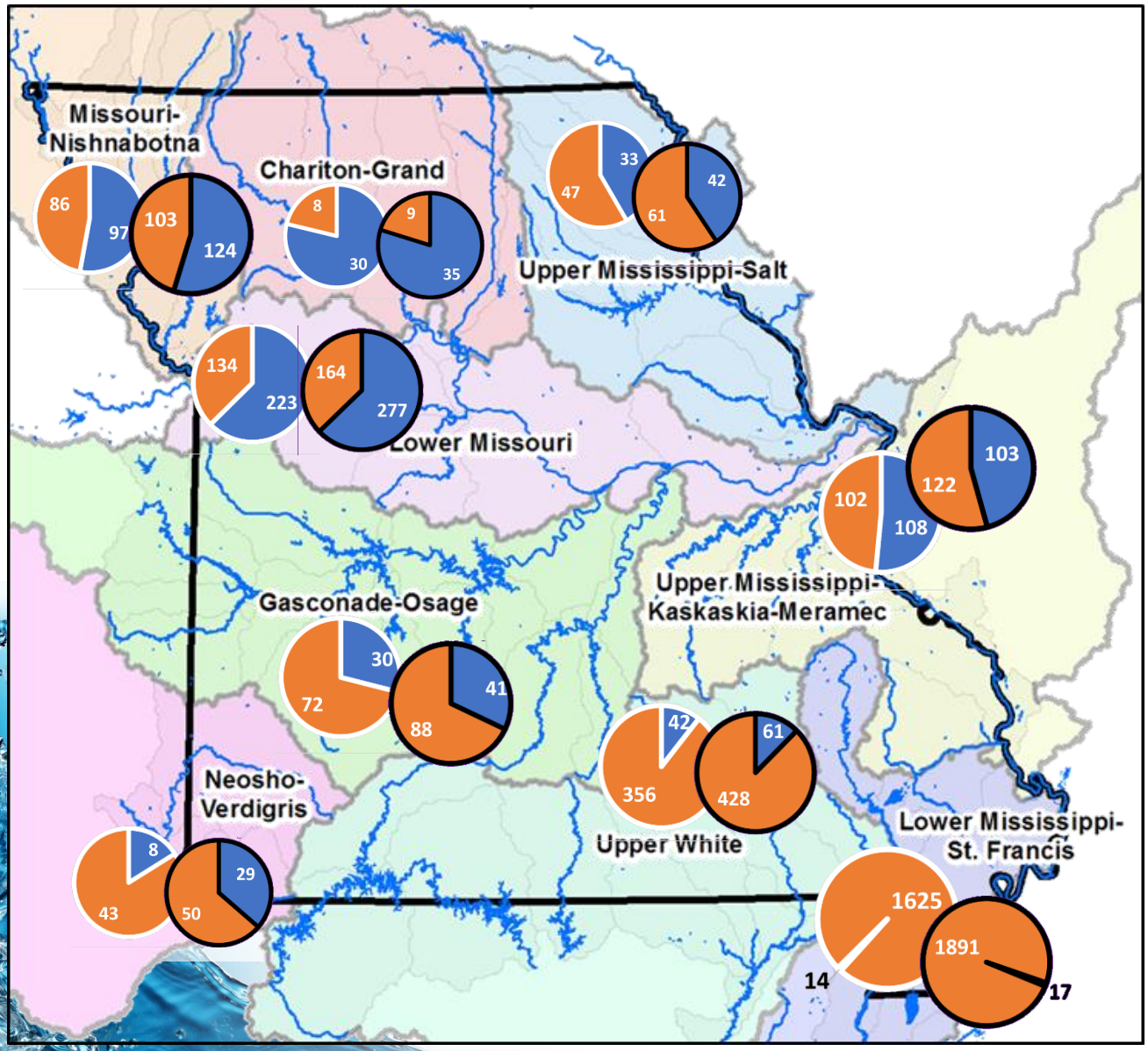
Current Consumptive Water Demands (MGD) by Source

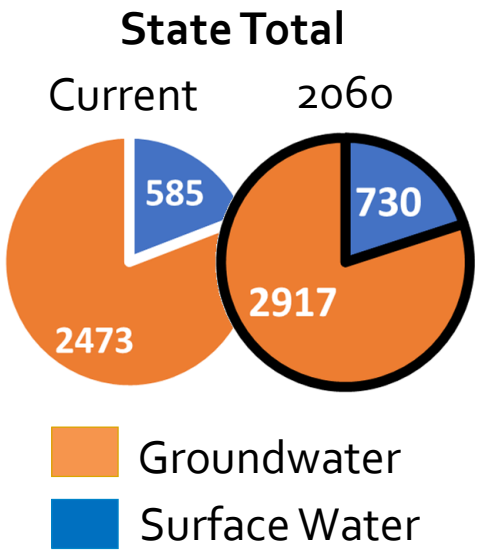




MISSOURI WATER RESOURCES PLAN

Current and 2060 Consumptive Water Demands (MGD) by Source





MISSOURI WATER RESOURCES PLAN

Consumptive & Infrastructure Technical Workgroup Feedback

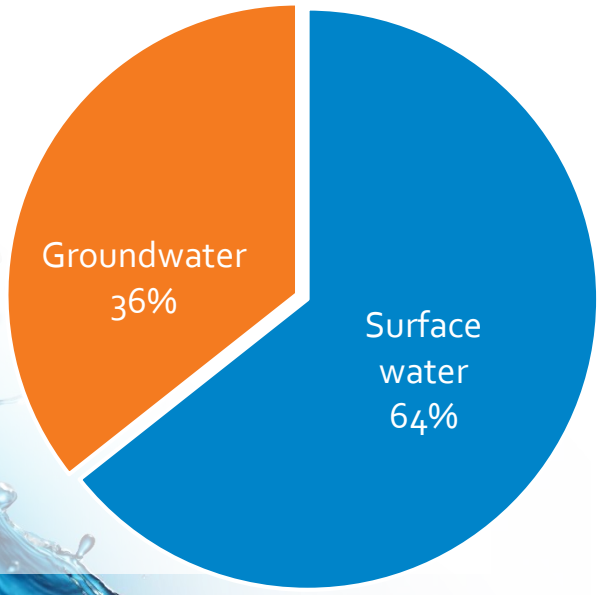
- Reviewed approach and methods for each consumptive demand sector and gave feedback on appropriateness of data
  - Reviewed Woods & Poole demographic projection series
  - MoDNR Water Users Database and Census of Public Water Systems
  - Brought "economic centers" to team's attention which resulted in a revision to the methodology
- Provided feedback on demand sector naming conventions (Municipally-provided Public Supply changed to Major Water Systems)
- Discussion of ways to quantify infrastructure need
- Provided data and regional reports
- Collected data regarding recycled water demand offset undertaken by KC Water
- Key take away messages:
  - High diversity in the state – water use, geology, geography
  - Recession impacted population trajectory, future highly uncertain
  - Regionally, southwest Missouri is growing the fastest; urban areas continue to grow
  - Infrastructure needs are great and will only increase

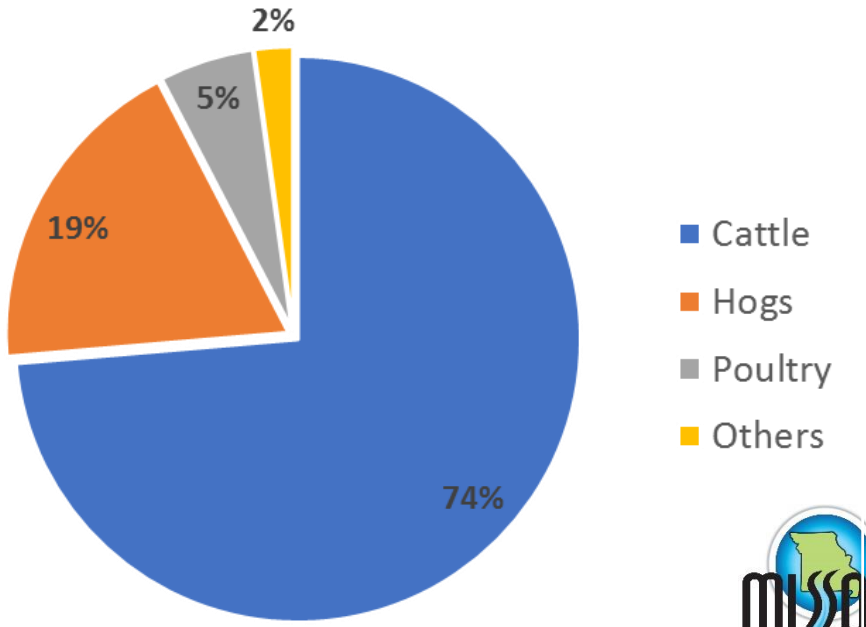
Demand Forecasting - Agriculture Needs

MISSOURI WATER RESOURCES PLAN

Agriculture Demands - Livestock

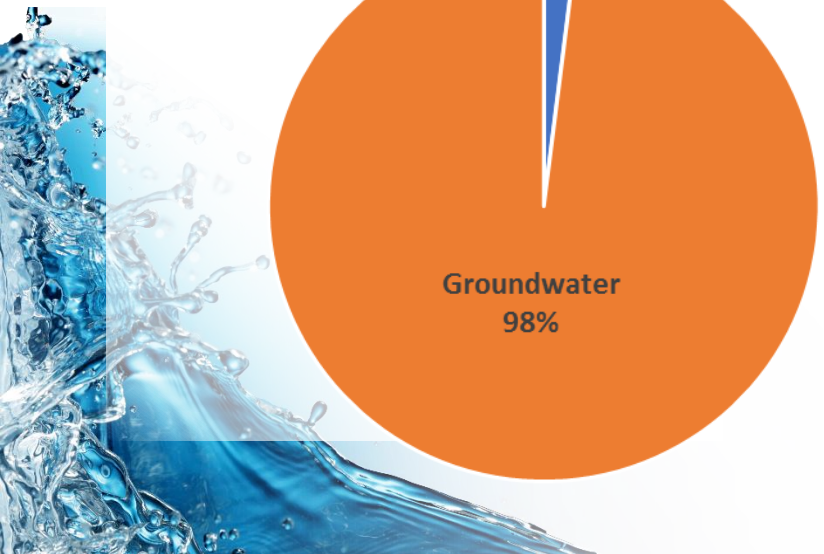
- Based on number of animals in the state – poultry, cattle, hogs, etc.
- Estimated to use 112 MGD of water annually
- Increase to 169 MGD in 2060

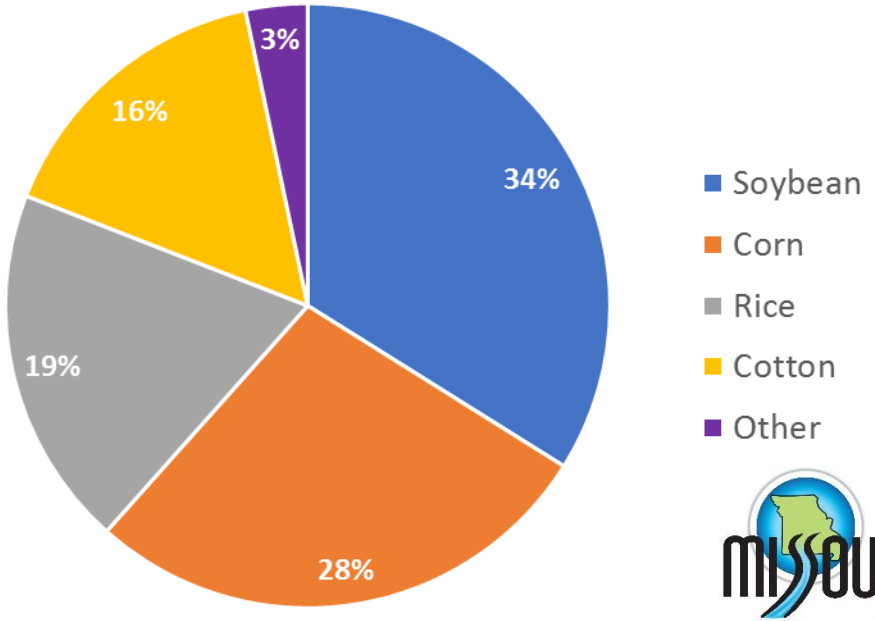




Agriculture Demands – Crop Irrigation

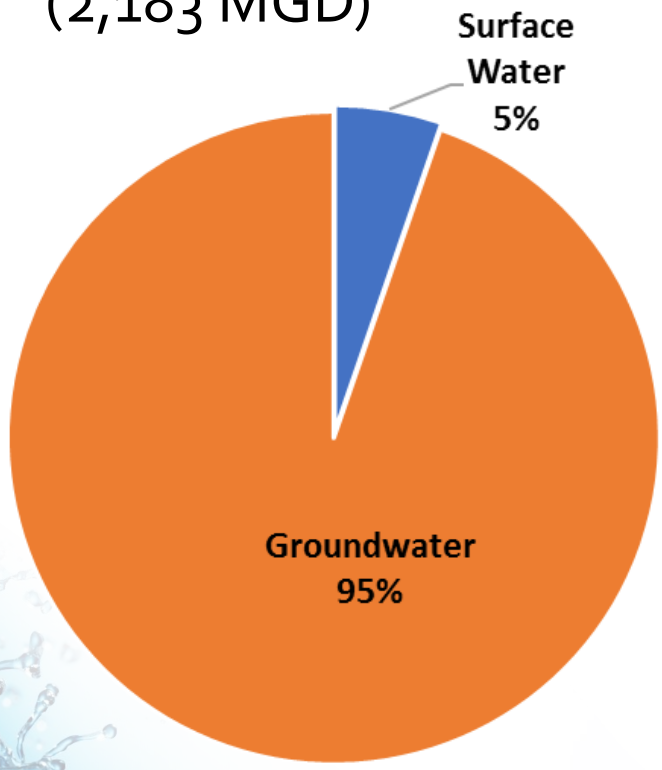
- Based on irrigated acres by crop type and water requirement
- 1.7 million acres utilize 2.3 million acre-feet (2,071 MGD) for average weather year
- Increase to 2.7 million acre-feet (2,465 MGD) in 2060
- 98% groundwater

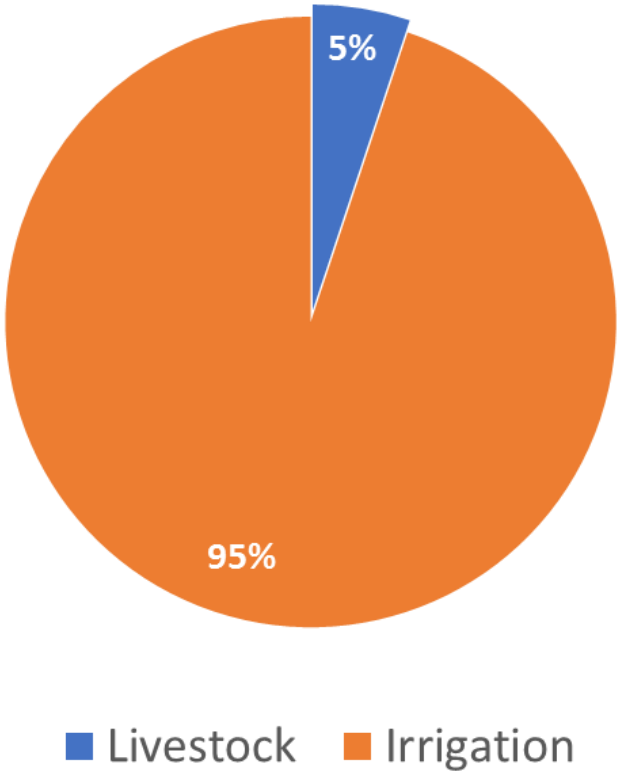




Combined Current Agricultural Water Use

- Total Agricultural Water Use in 2016 is 797 Billion Gallons (2,183 MGD)



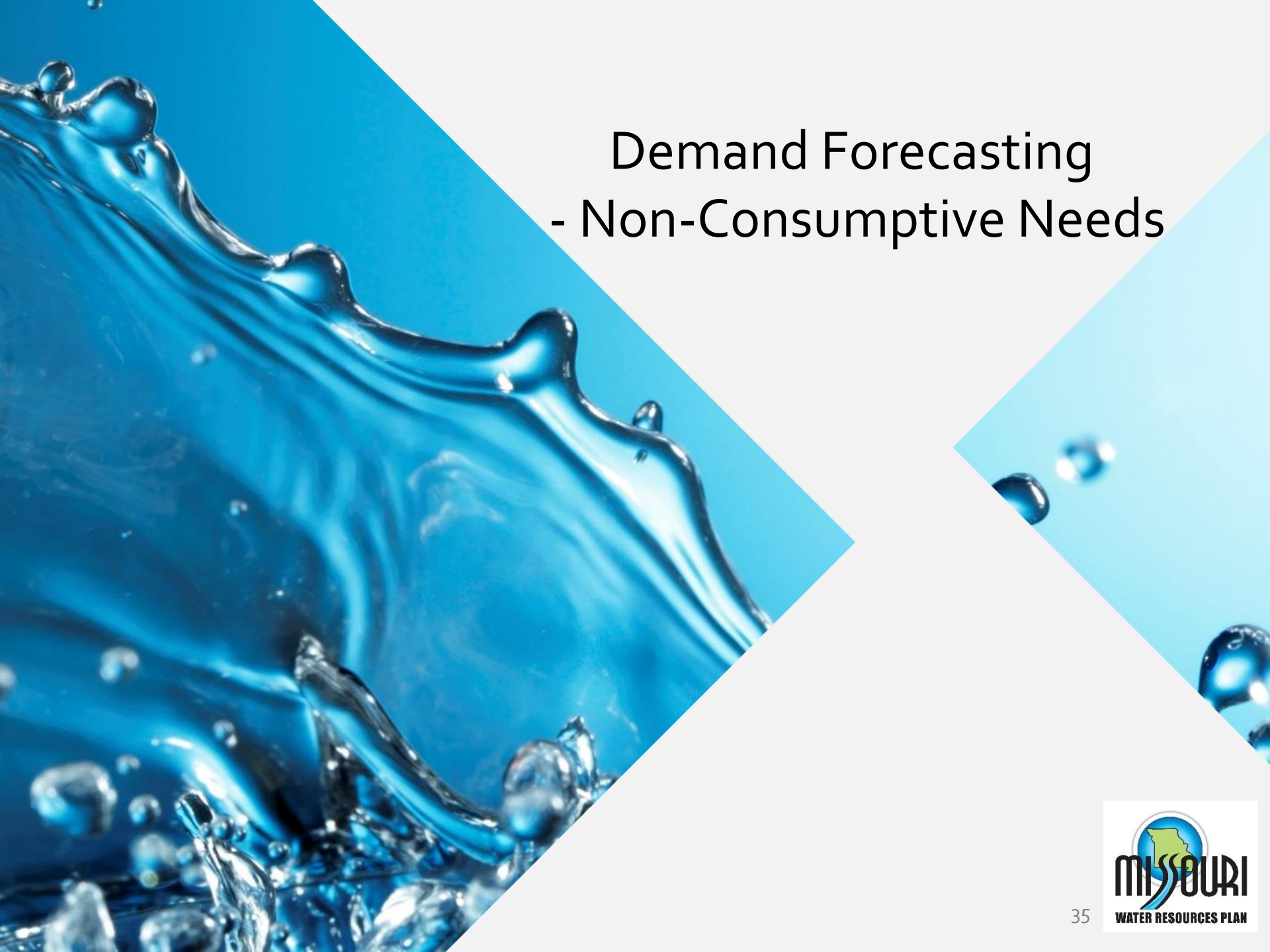


Agriculture Technical Workgroup Feedback

- Reviewed approach for livestock and irrigation demand estimations
- Reviewed pros/cons of potential data sources – MoDNR's Major Water Users Database, Census of Agriculture, FSA
- Provided feedback and guidance on the irrigation efficiency assumptions
- Discussion of the state's 2012 drought response, e.g. drilling new wells and the impact on agriculture water demand
- Provided clarification that food processing and ethanol plant water use is included in the Self-Supplied Nonresidential sector
- Identified additional data sources – Sod Producers Association
- Key take away messages:
  - Agriculture need is an important consideration for the state's supply
  - Use of irrigation water has become more efficient over time
  - Agriculture users have to plan for infrastructure costs as well – e.g. piping and pumps for irrigation and pond development for livestock watering
  - Agriculture sector also thinks about back-up supply during times of drought much like public water suppliers do
  - Irrigation is highly reliant on groundwater while livestock relies on both surface water and groundwater, depending on geographic location; pockets of temporary shortages exist

What do the Consumptive Demands By Sector Tell Us?

- Statewide, the majority of demands are groundwater
  - Groundwater demands are highest in 6 of 9 basins
  - Northern Missouri is more reliant on surface water
  - Nearly 82% of statewide consumptive demands are groundwater
  - This trend continues into the future
- Many public supplies rely on surface water supply
  - Public supply is the majority of all consumptive demands for surface water in 6 of 9 basins
  - Agriculture is also a major surface water demand, comprising the majority of demands in the remaining 3 basins
- Agriculture irrigation is an important consumptive need, especially in the bootheel region; there is potential for this to increase by 17%.



Demand Forecasting
- Non-Consumptive Needs

MISSOURI WATER RESOURCES PLAN

Non-Consumptive Demand
Overview of Approach

Include in Demands Chapter
(where applicable)

- How water is used
- What activities does water support
- Importance of sector to the state
- Quantify water needs
- Map locations of key use and infrastructure
- Future outlook
- Identify data gaps and needs

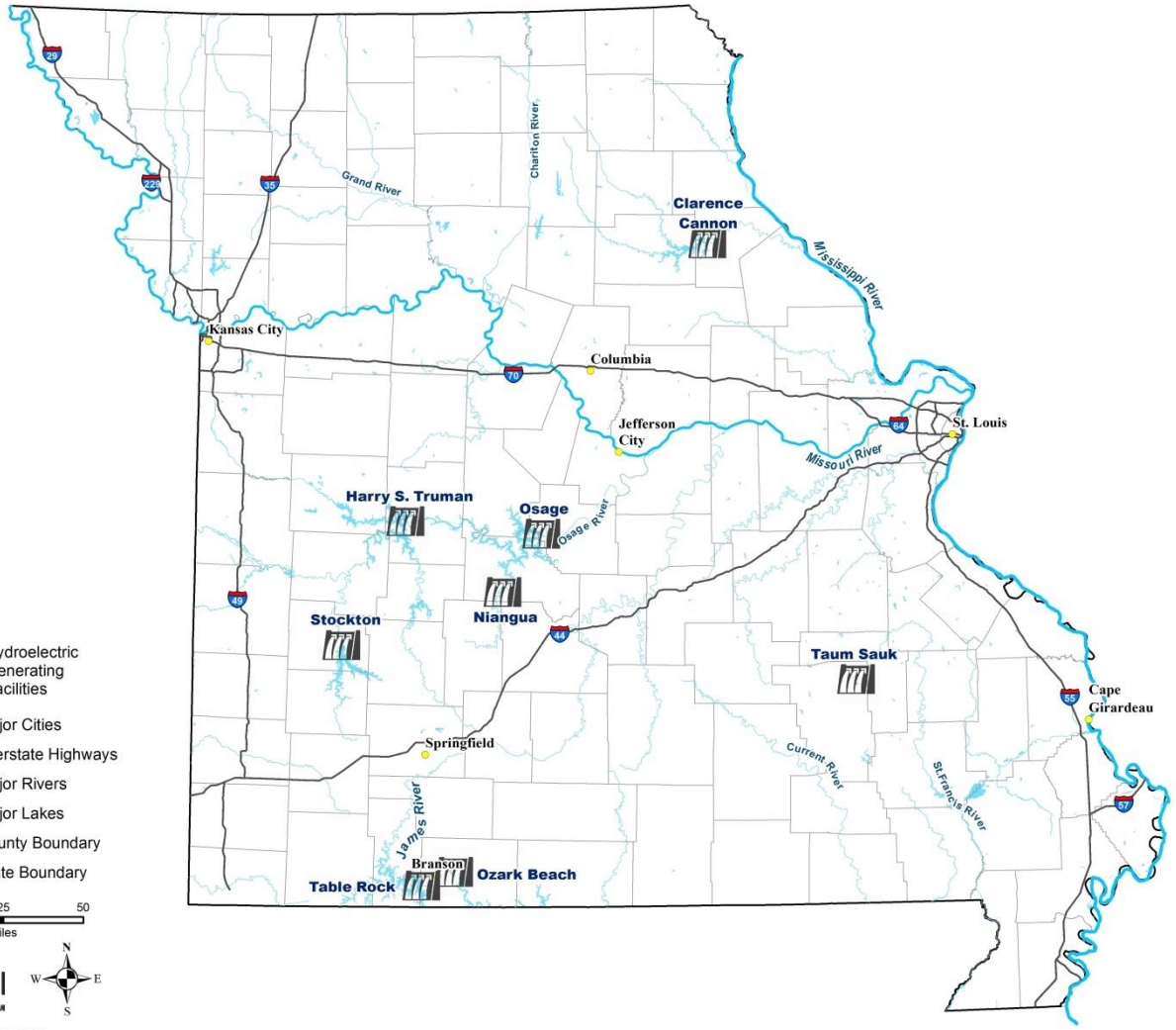
MISSOURI WATER RESOURCES PLAN

Non-Consumptive Demand
Hydroelectric Power Generation

- Introduction and definitions
  - Renewable resource generation graphic
  - General information
  - Clean energy discussion
- Hydropower facilities
  - Table, map, and paragraph description for each
- Current water use characteristics
  - Source of water and general information
- Hydroelectric benefits
  - NED benefits for USACE-operated reservoirs
- Future outlook
  - Potential development options (Ameren IRP)

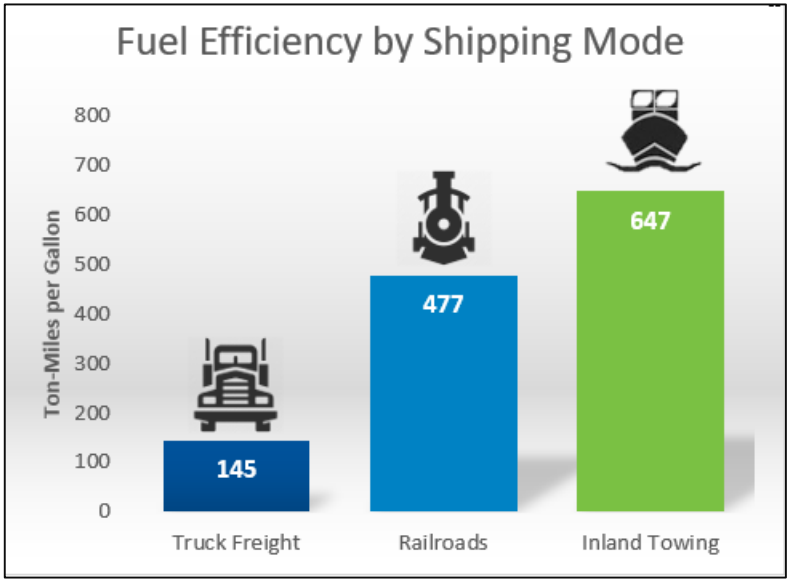
Plant Name
Clarence Cannon
Harry S. Truman
Niangua (Tunnel Dam)
Osage (Bagnell Dam)
Ozark Beach (Powersite Dam)
Stockton
Table Rock
Taum Sauk

Non-Consumptive Demand
Hydroelectric Power Generation



Non-Consumptive Demand
Commercial Navigation

- Introduction and definitions
- Navigation infrastructure
  - Locks and dams
  - Missouri River Basin water-control reservoirs
  - Port authorities and toll ferries
  - Commercial passenger vessels
- Tonnage
- Economic value
- Shipping patterns
- Water requirement
- Future outlook



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Non-Consumptive Demand
Commercial Navigation

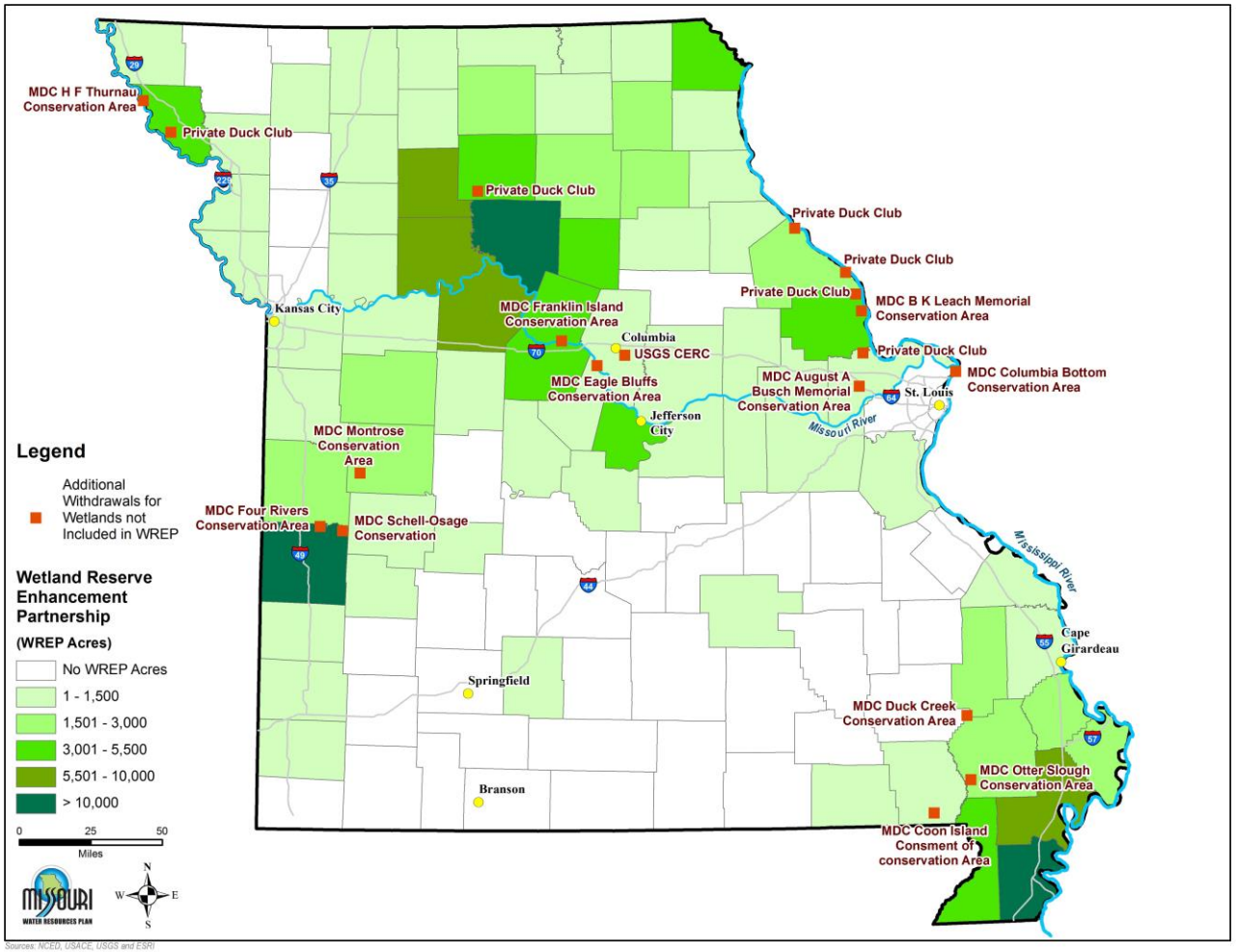
Non-Consumptive Demand Wetlands

- Introduction
  - Wetland function and history
  - WREP program
  - Additional state-run conservancy areas
  - Map of acreage with MDC wetland pumping areas and private duck club registration
- Economic importance
  - WREP payments and economic impact
  - Hunters and bird viewing
- Quantified water withdrawals

145,000 acres in the WREP

WREP plus MDC managed areas estimated to pump or divert 104,000 acre-feet of water annually

Non-Consumptive Demand Wetlands



Source: USDA-NRCS GIS Layer of WREP acreage

MISSOURI WATER RESOURCES PLAN

Non-Consumptive Demand
Aquaculture and Fish Hatcheries

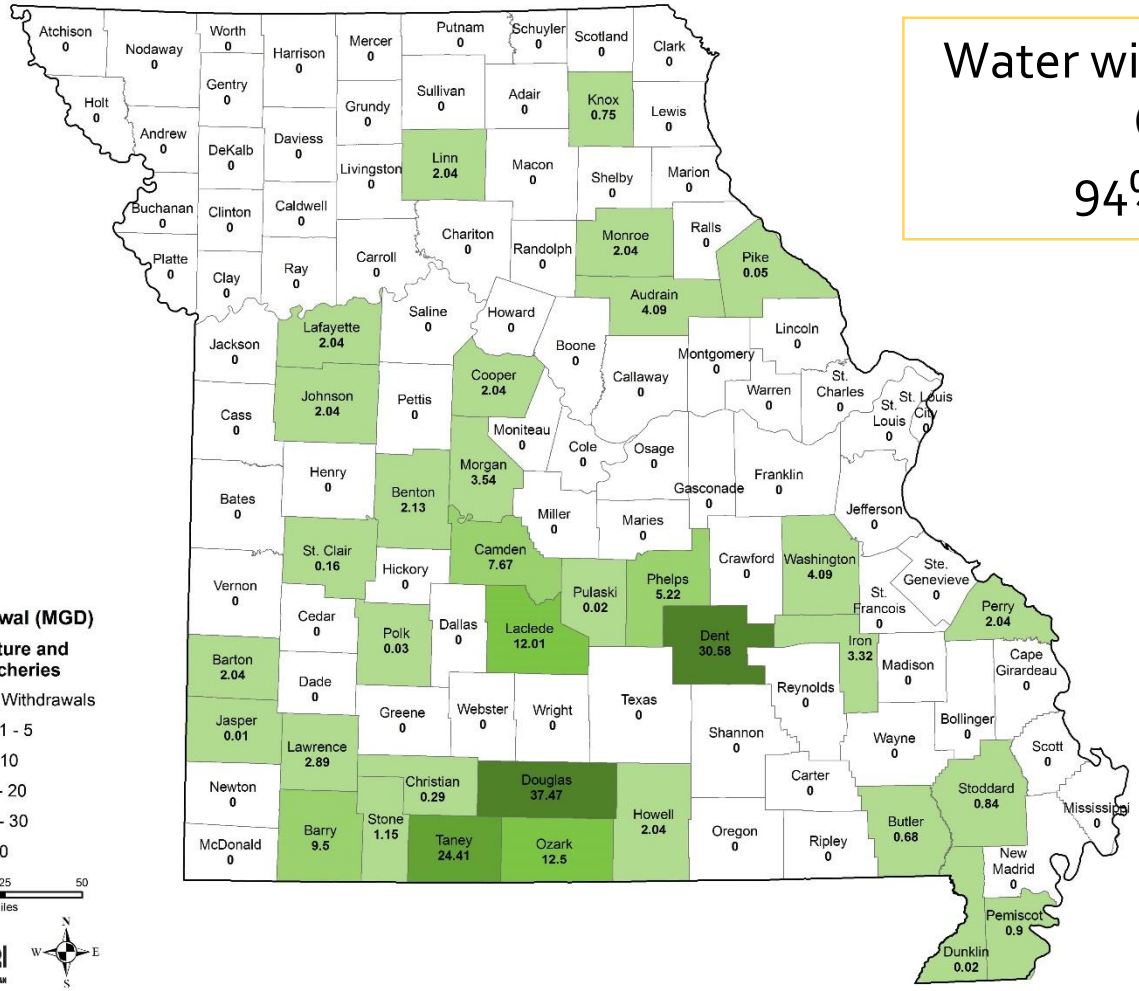
- Introduction
  - History
  - Current MDC and FWS hatcheries
  - Private aquaculture industry
  - Aquaculture-related businesses
- Economic importance
  - USDA-reported private aquaculture sales
  - Fishing impact
  - MDC's five cold-water hatchery impacts
- Quantified water withdrawals
  - USGS by county by source
  - Includes federal, state, and private operations

Aquaculture is the farming and cultivation of cold and warm water organisms such as fish or crustaceans for food, restoration, conservation, or sport fishing

USGS estimates aquaculture withdrawals for Missouri, which is inclusive of private, federal, and state operations

54% of withdrawals from groundwater

Non-Consumptive Demand
Aquaculture and Fish Hatcheries



Source: USGS 2010 Water Use Data (Maupin et al. 2014)

Water withdrawals of 181 mgd
(202,750 acre-ft)

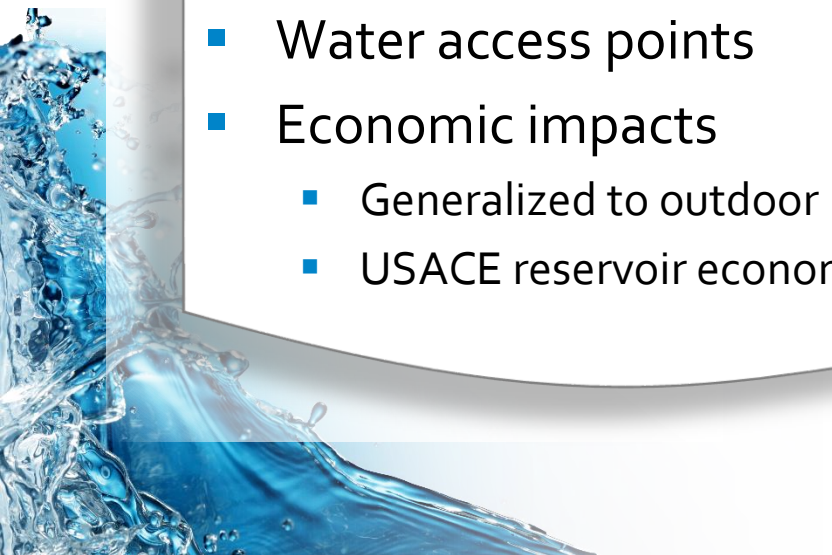
94% surface water

Shepherd of the Hills
MDC website

Neosho
FWS website

Non-Consumptive Demand
Water-Based Outdoor Recreation

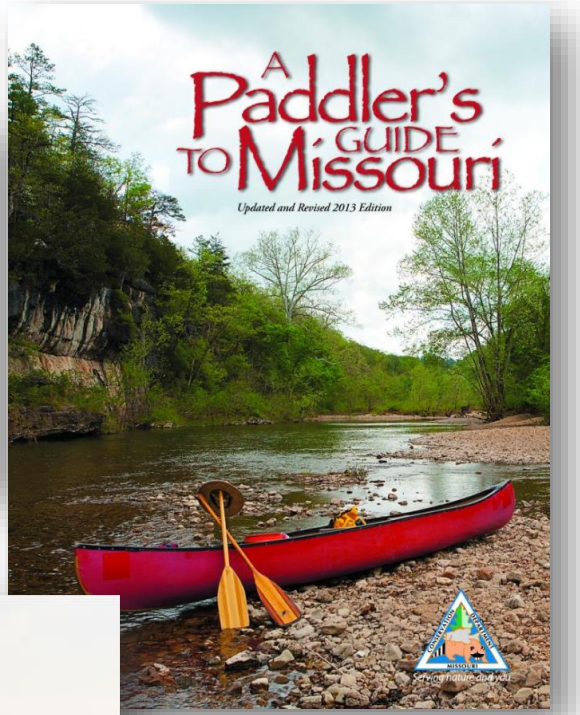
- Introduction
- Designated waters suitable for recreation
- Water bodies
  - Lakes operated by USACE
  - MDC-managed waterbodies
  - Trout waters
  - Float rivers and river trails
  - Missouri Outdoor Recreational Access Program
- Water access points
- Economic impacts
  - Generalized to outdoor recreation
  - USACE reservoir economic impact



Non-Consumptive Demand
Water-Based Outdoor Recreation

- motorboating
- skiing
- sailing
- swimming
- canoeing
- fishing
- hunting
- floating
- diving
- wading
- rafting
- paddle boarding
- kayaking

Photo from whiteriverkayaking.com



Stockton Lake
Photo from USACE Website

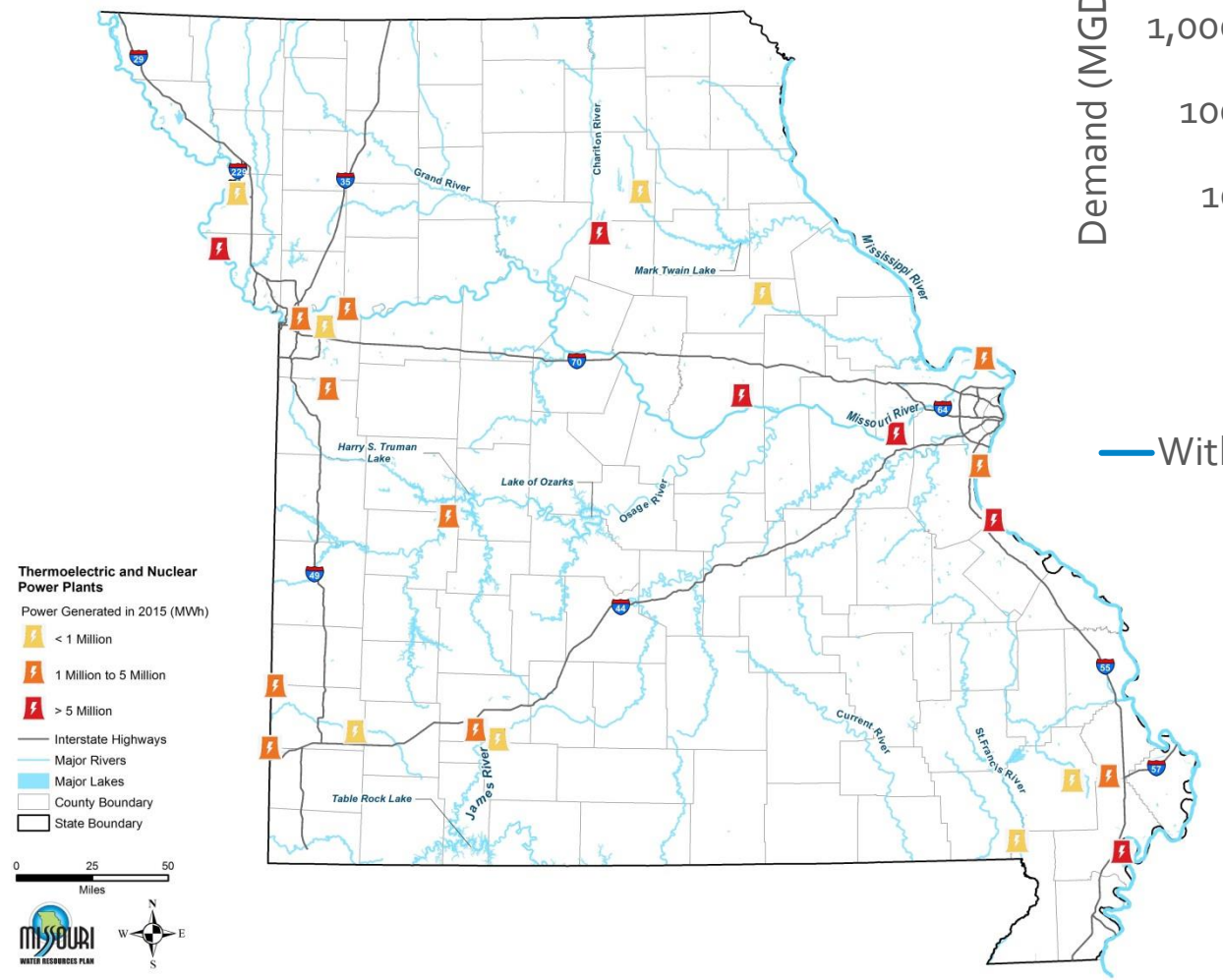
Non-Consumptive Demand Thermoelectric

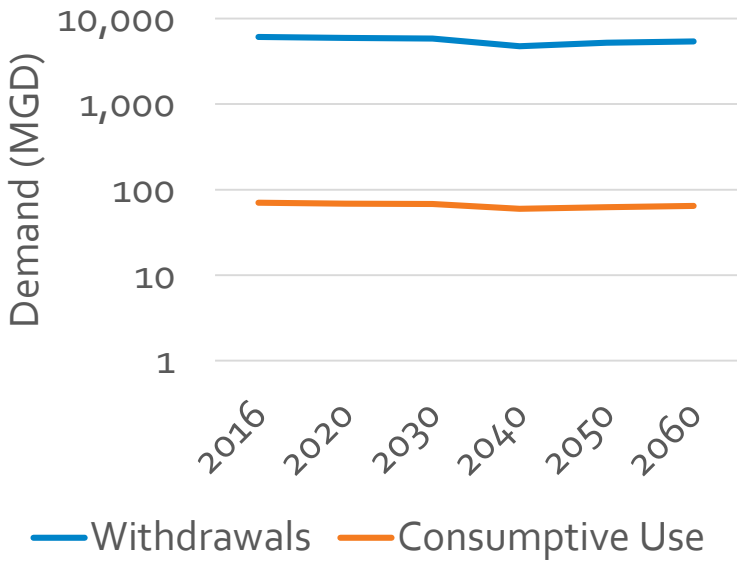
- Introduction and definitions
  - Map of facilities
  - Includes nuclear facility (noted in report)
- Current water use characteristics
  - Major Water User database
- Water use and power generation
- Future thermoelectric power generation
- Future water demands
  - Consumptive and withdrawals
  - By county and source

87% of thermoelectric demands are supplied by surface water

Only 1% of water withdrawn is consumed

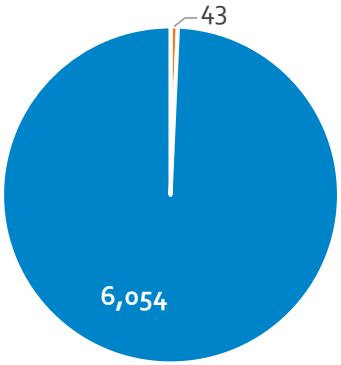
Non-Consumptive Demand Thermoelectric



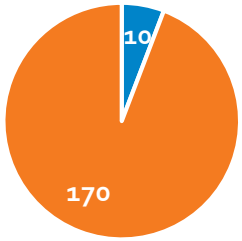


Non-Consumptive Withdrawals Summary Current Use

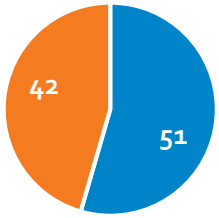
Thermoelectric Withdrawals



Aquaculture Withdrawals



Wetland Withdrawals



Surface Water Groundwater

	MGD	AFY
Thermoelectric	6,096	6,828,713
Aquaculture	181	202,343
Wetlands	93	104,350
TOTAL	6,370	7,135,406

MISSOURI WATER RESOURCES PLAN

Non-Consumptive Technical Workgroup Feedback

- Each representative provided direct feedback and guidance for the sector they represent
- Suggested separating "Aquaculture" and "Wetlands" and adding MDC pumping to "Wetlands"
- Many additional studies were identified and provided to the team:
  - Ameren IRP
  - Economic Impacts Study for Public Ports
  - Iowa Department of Transportation
  - Missouri State Freight Plan
  - River Trails and Paddler's Guide
  - Commercial Fisheries, MDC
  - The 2011 Economic Impacts of Fishing, Hunting, and Wildlife Viewing in Missouri

Non-Consumptive Technical Workgroup Feedback

- Through meetings, worked to refine language and presentation of sector for the demands chapter – helped to capture what was important to portray
- Hydropower TWG member provided direct review of some language for the water plan, more review and input to come
- Worked directly with MDC to collect additional water use data and other reports
- Provided valuable input into other components of the state plan as well – supply, infrastructure, and water quality; one member suggested use of "median" flow record over "average"
- Key take away messages:
  - While not consumed, these sectors rely on the quantity and quality of water to deliver the services they provide to the economy and environment
  - These sectors are hugely important to the economic activity of the state

Breakout Activity

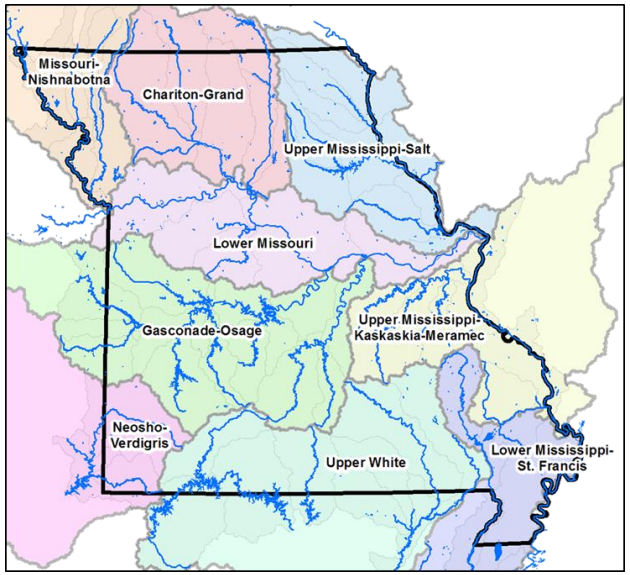
MISSOURI WATER RESOURCES PLAN

Supply Availability

MISSOURI WATER RESOURCES PLAN

Surface Water Supply Analysis Goals

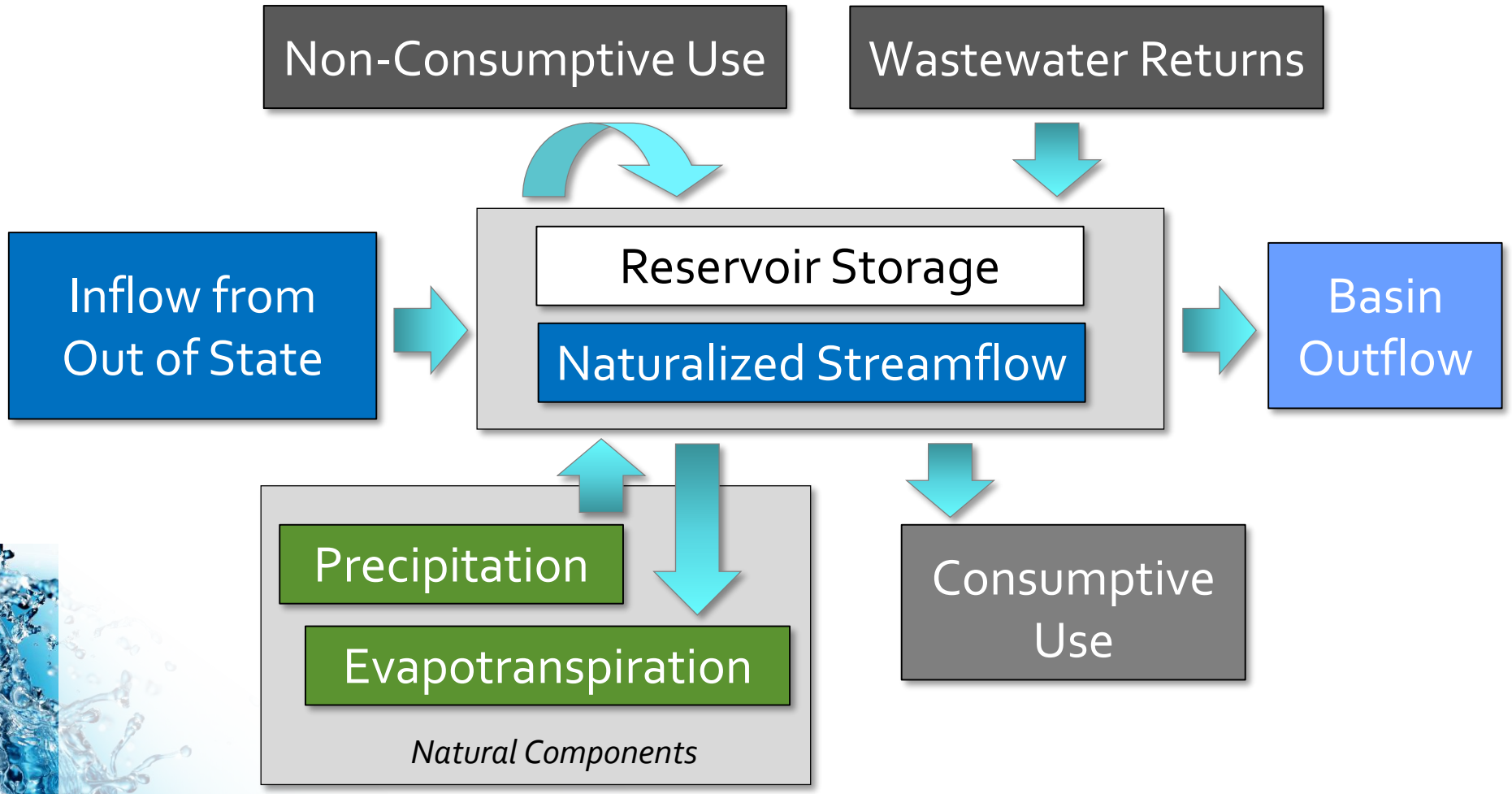
- At a HUC4 level, evaluate and summarize:
  - Surface water availability (streamflow)
  - Demands, both consumptive and non-consumptive
  - Gaps in available supply compared to demands
- Evaluate wet, dry, and average years on an annual and monthly basis
- Use results to support the infrastructure task
- Establish baseline for scenario planning



Missouri's HUC4 Basins

MISSOURI WATER RESOURCES PLAN

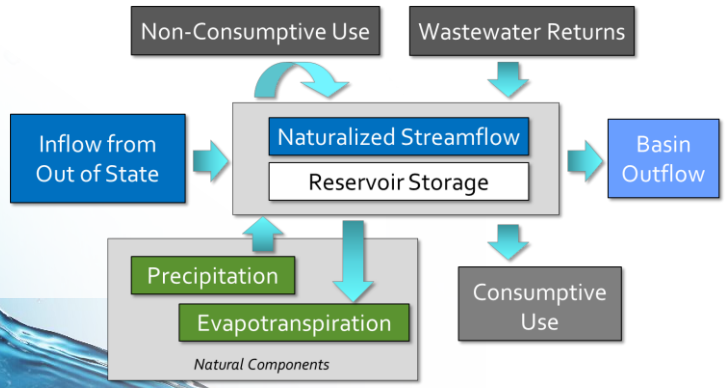
Surface Water Budget

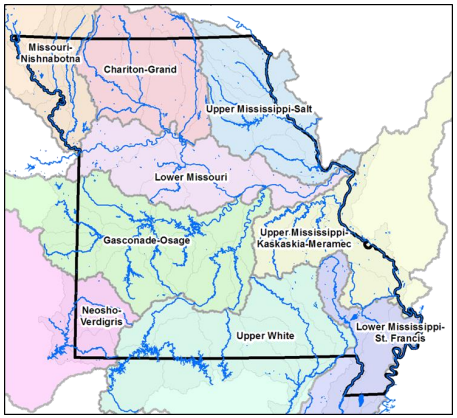


MISSOURI WATER RESOURCES PLAN

HUC4 Current Surface Water Budget (in/yr)

		Values in Inches per Year, based on Average Annual Conditions										
		Natural Components		Streamflow				Withdrawals and Returns				Outflow
HUC4	Name	Precipitation	Evapo-transpiration	Streamflow (from Out of State)	Streamflow (from an in state HUC4)	Streamflow (generated in HUC4)	Total Streamflow	Non-Consumptive Withdrawals	Non-Consumptive Returns	Consumptive Withdrawals	Wastewater Returns	Basin Outflow
711	Upper Mississippi-Salt	40.1	23.7	210.1	0.0	12.0	222.1	1.3	1.2	0.1	0.1	222.1
714	Upper Mississippi-Kaskaskia-Meramec	45.4	27.4	449.7	0.0	13.1	462.8	3.0	3.0	0.3	0.7	463.1
802	Lower Mississippi-St. Francis	48.4	25.7	691.9	0.0	7.8	699.7	0.0	0.0	0.1	0.1	699.7
1024	Missouri-Nishnabotna	36.2	22.5	183.1	0.0	10.0	193.1	5.2	5.3	0.6	0.1	192.8
1028	Chariton-Grand	38.6	22.8	3.3	0.0	10.4	13.7	1.9	1.9	0.1	0.0	13.6
1029	Gasconade-Osage	44.5	27.2	4.2	0.0	13.8	18.0	0.3	0.3	0.0	0.0	18.0
1030	Lower Missouri	42.4	24.9	77.9	42.4	12.5	132.8	4.5	4.4	0.5	0.4	132.7
1101	Upper White	46.8	28.1	3.7	0.0	18.1	21.8	0.2	0.2	0.1	0.1	21.8
1107	Neosho-Verdigris	46.0	28.1	0.0	0.0	13.4	13.4	0.0	0.0	0.2	0.2	13.4





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MISSOURI WATER RESOURCES PLAN

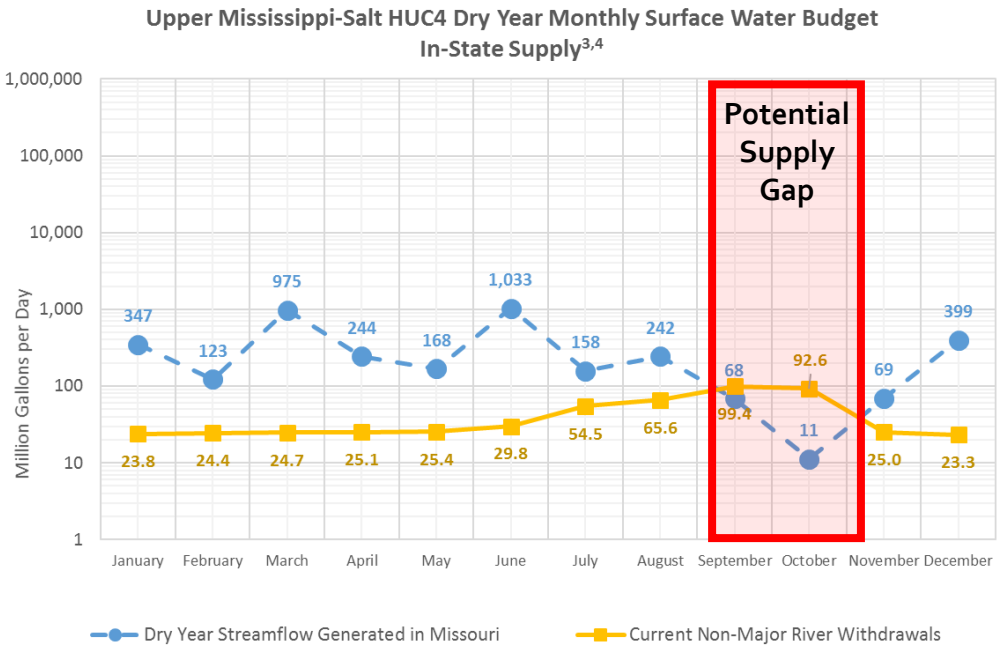
What Do the HUC4 Surface Water Budgets Tell Us?

On an ***average annual*** basis:

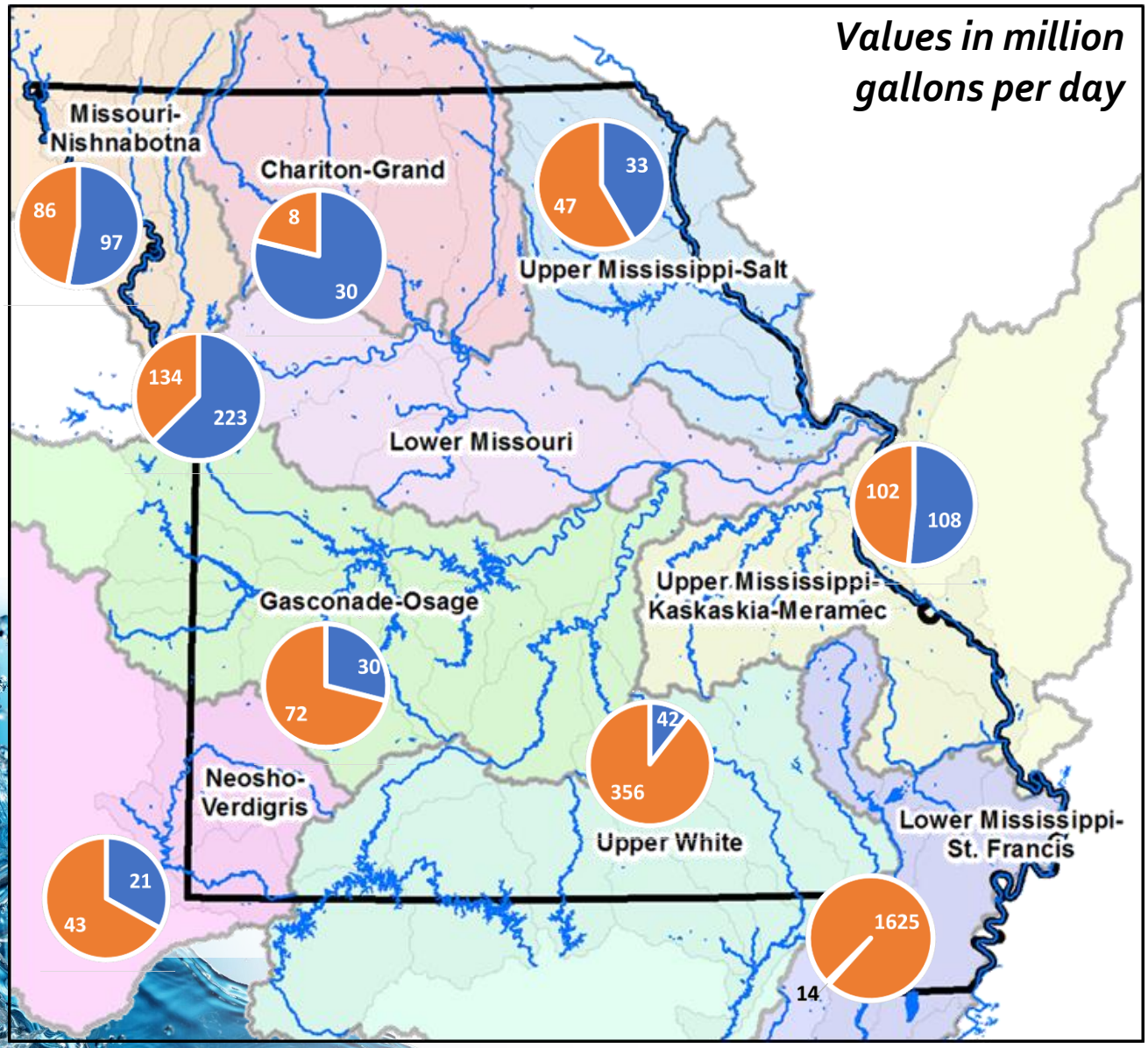
- Flows from out of state are dominant in most basins
- Consumptive withdrawals are typically:
  - < 1% of total streamflow
  - 1%–5% of streamflow generated in the basins
- Supply far exceeds demand at HUC4 scale (no gaps)

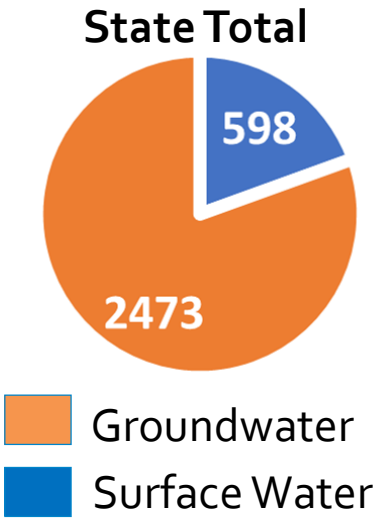
On an ***monthly*** basis:

- Gaps in supply and demand begin to appear, but are limited and infrequent



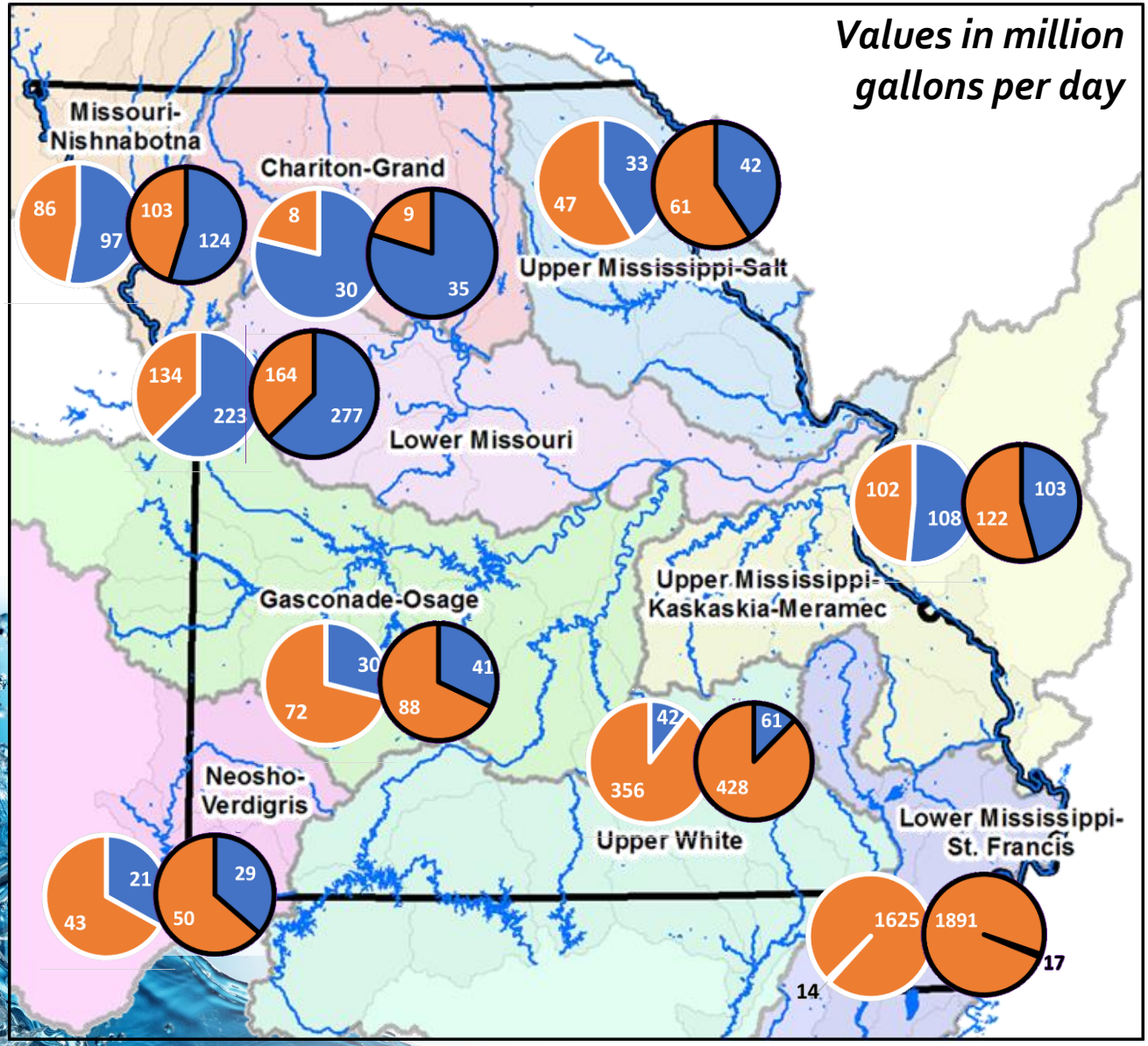
Statewide, Surface Water Demands Are 20% of Total Consumptive Demands

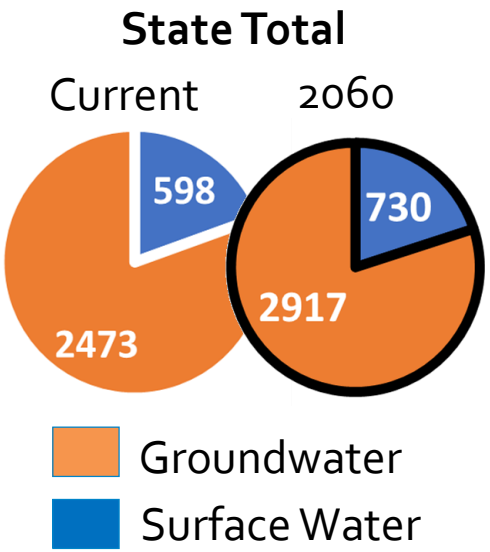




MISSOURI WATER RESOURCES PLAN

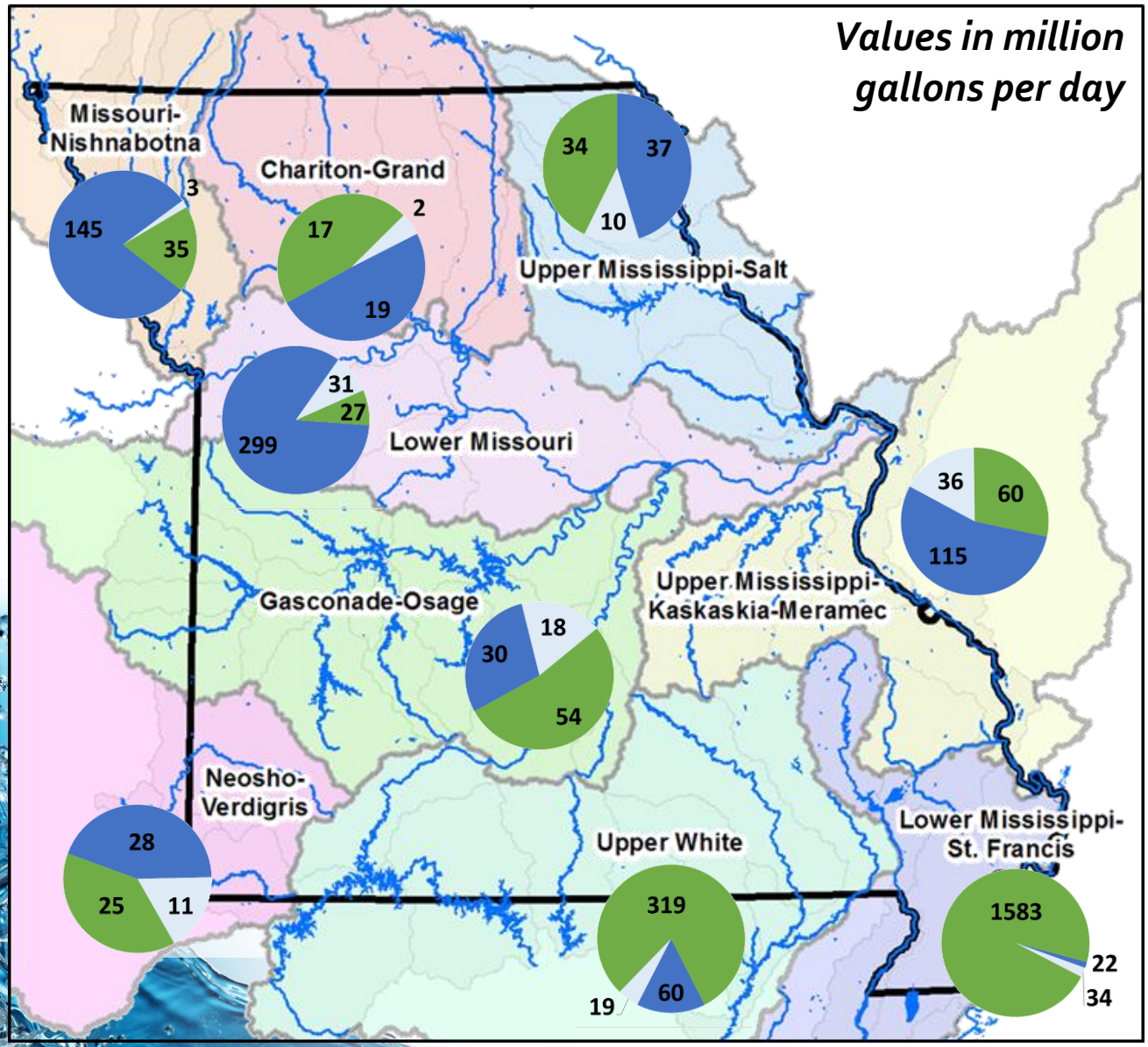
Surface Water Demands for Consumptive Uses Are Projected to Increase by 25% by 2060

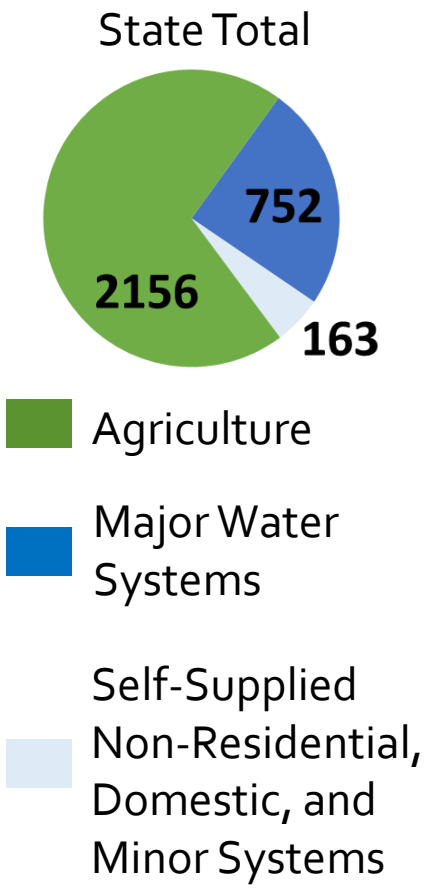




MISSOURI WATER RESOURCES PLAN

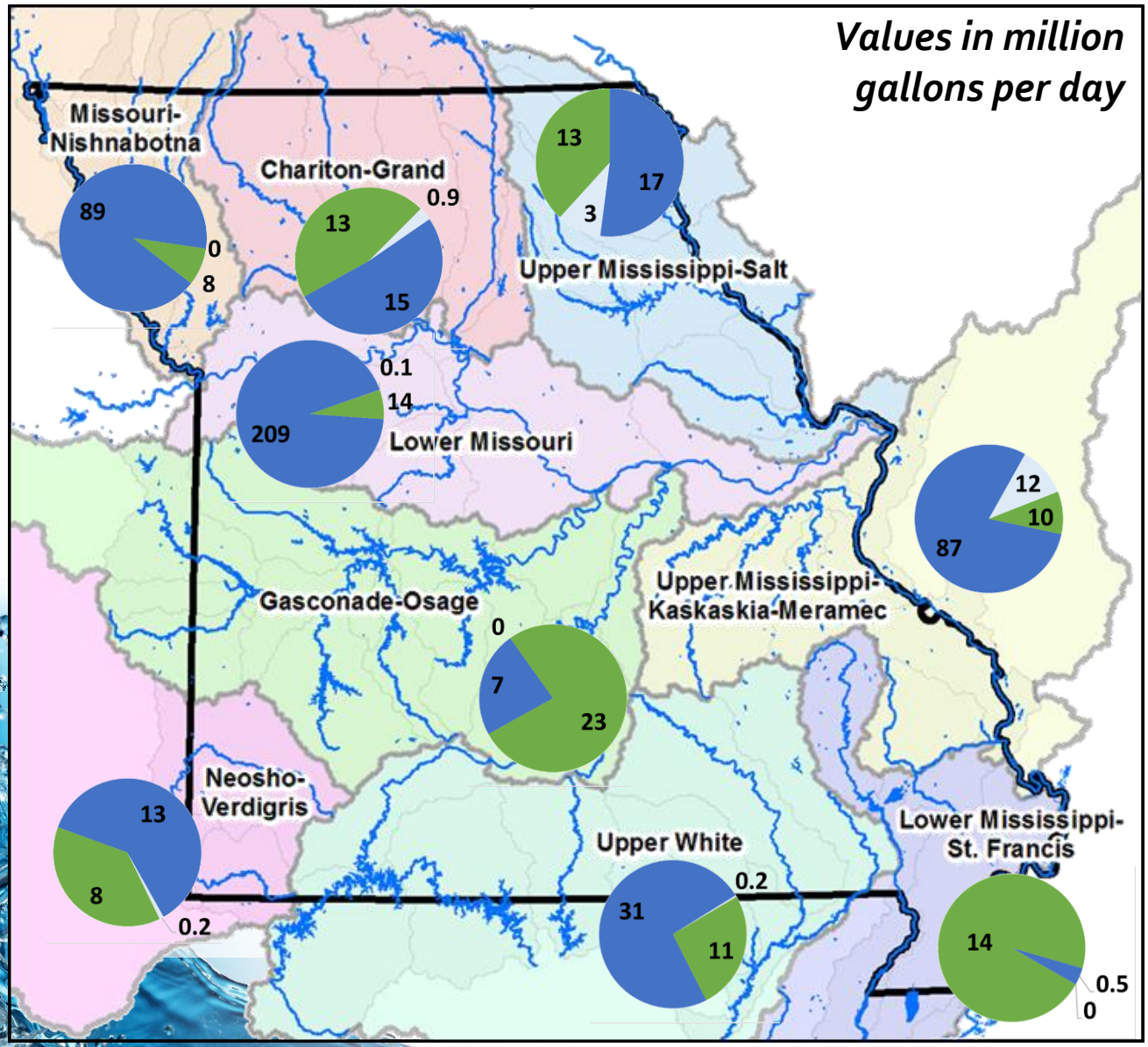
Agriculture and Livestock Account for 70% of Current **Total** Consumptive Water Demands

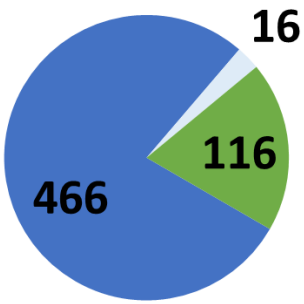




MISSOURI WATER RESOURCES PLAN

Major Water Systems Account for 78% of Current **Surface Water** Consumptive Demands





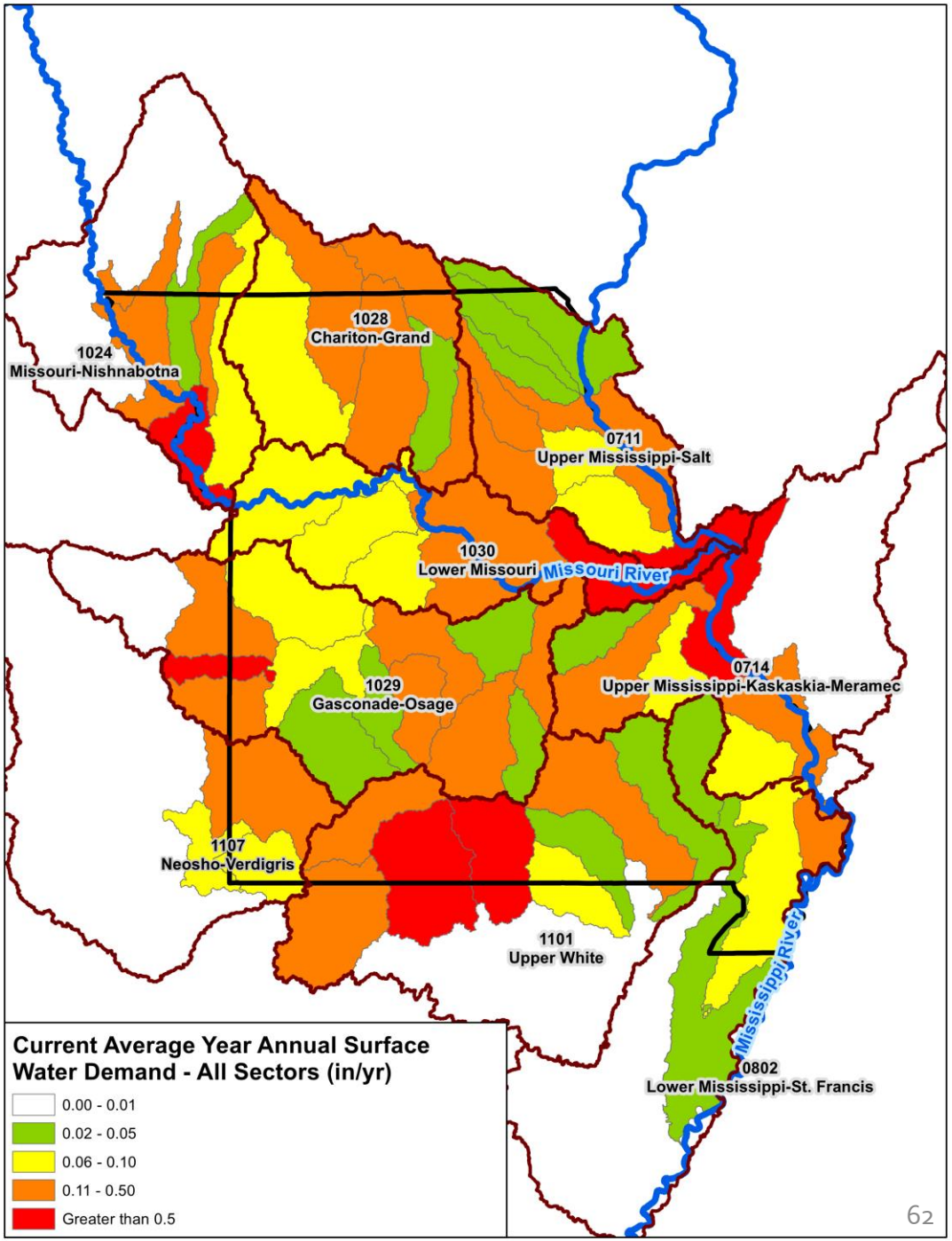
Agriculture

Major Water Systems

Self-Supplied Non-Residential

MISSOURI WATER RESOURCES PLAN

Current Average Annual Surface Water Demand for All Water Use Sectors



MISSOURI WATER RESOURCES PLAN

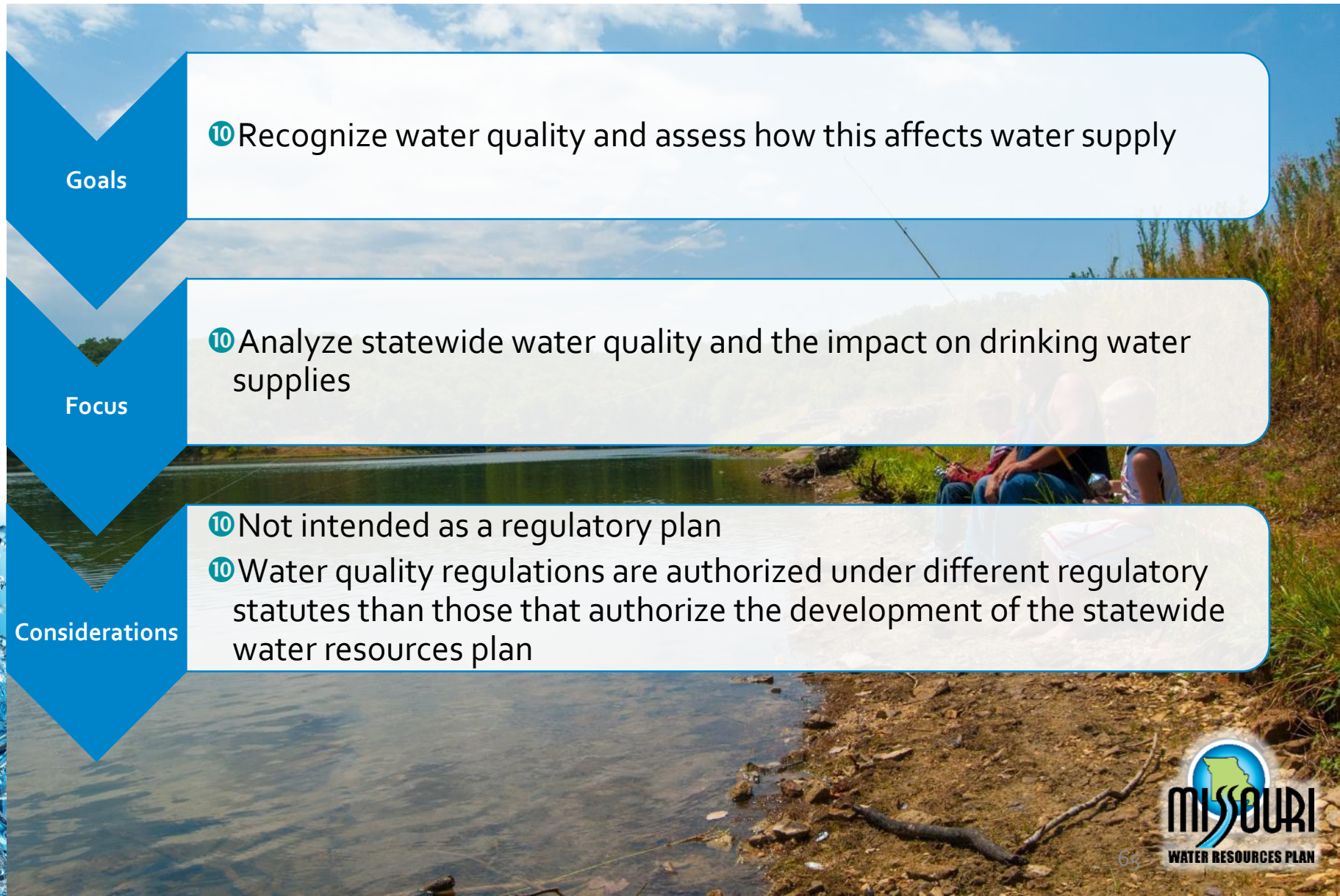
Feedback Received from Technical Workgroups

- Consider using *median* annual streamflow as part of the water budgets (large flow events may skew the average).
- Consider impacts to supply that are not captured in the previous 30 years of record.
- Consider adjusting demands when comparing to the dry year, since demands may be higher in dry years.
- Given that the Missouri River provides water supply to 45% of Missourians, the Water Plan should discuss and emphasize it's significance.
- Double check specific demands (e.g., Springfield and Joplin) to be sure they are appropriately represented.
- Northern Missouri's heavier reliance on surface water supplies (due to poor groundwater quality in deep aquifers) makes it more susceptible to stress during droughts.

Water Quality

MISSOURI WATER RESOURCES PLAN

Water Quality Task Summary



Goals

- Recognize water quality and assess how this affects water supply

Focus

- Analyze statewide water quality and the impact on drinking water supplies

Considerations

- Not intended as a regulatory plan
- Water quality regulations are authorized under different regulatory statutes than those that authorize the development of the statewide water resources plan

Water Quality Assessment Overview

- Summarize Current Water Quality Statewide and By Major Watershed (HUC_4)
- Focus on Source Water Quality Impacts to Treatment and Infrastructure Costs
- Assess Spatial Trends and Identify Regional Areas of Concern
- Assess Trends in Water Quality Over Time
- Evaluate Emerging Issues

Source Water Quality and Impacts to Drinking Water Treatment Cost

- The quality of source waters can drive infrastructure
  - Treatment processes
  - Treatment costs
  - Potential source water change
- Assessment of potential issues with drinking water treatment resulting from source water quality
  - Geographic relationships
  - Temporal trends and future impacts
    - Account for variable flow and seasonality
- Ties into infrastructure, supply, and demand analyses

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Relative Water Quality Drivers/Thresholds by Treatment Type

Treatment Type	Drivers/Thresholds for Treatment						
	Pathogens	TOC	Suspended Solids and Turbidity	Salinity	Hardness	Nutrients/Taste and Odor	Emerging Contaminants
Direct Filtration[1]	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Conventional[1]	MED	MED	MED	LOW	LOW	LOW	LOW
Conventional + Enhanced Coagulation	MED	MED-HIGH	MED-HIGH	LOW	LOW	LOW	LOW
Conventional + Lime Softening	MED	MED-HIGH	MED-HIGH	LOW	HIGH	LOW	LOW
Conventional + Ozone/UV	MED-HIGH	MED-HIGH	MED-HIGH	LOW	LOW	MED-HIGH	MED-HIGH
Conventional + GAC	MED	MED-HIGH	MED-HIGH	LOW	LOW	MED-HIGH	MED-HIGH
Conventional + Membranes	MED-HIGH	MED-HIGH	MED-HIGH	LOW	LOW	LOW	LOW
Conventional + Nanofiltration/Reverse Osmosis	MED-HIGH	MED-HIGH	MED-HIGH	MED-HIGH	MED-HIGH	MED-HIGH	MED-HIGH

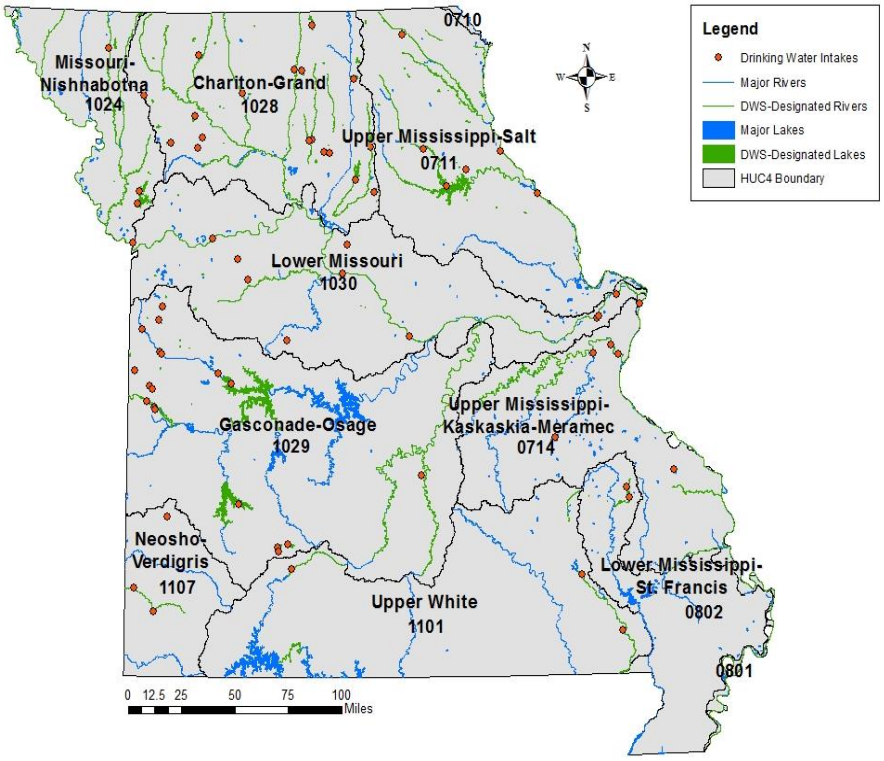
UV – Ultraviolet
GAC – Granular Activated Carbon

Treatment Cost Estimates for Varying Source Water Conditions

Treatment Type	Source Water Characteristics	Estimated Capital Costs (cost/gpd)
Direct Filtration[1]	Pristine water quality, consistent with few excursions.	$2-3
Conventional[1]	Moderate-high quality water, moderate to high frequency of excursions.	$3-4
Conventional + Enhanced Coagulation	High, natural organic matter (NOM) is precursor material to disinfection by-products (DBPs).	$3-4
Conventional + Lime Softening	High hardness in source water, often accompanied by high NOM, turbidity, and other treatment challenges.	$4-5
Conventional + Ozone/UV	High NOM (precursor to DBPs), high NOM and/or increased levels of pathogens, increased levels of bromide, moderate to severe taste and odor, potential for contaminants of emerging concern (CECs).	$4-5
Conventional + GAC	Similar to Conventional + Ozone/UV, but with lower risk of pathogens in source water.	$3-4
Conventional + Membranes	High pathogens and/or NOM.	$4-5
Conventional + Nanofiltration/Reverse Osmosis	Treats all of the challenging characteristics listed above for NOM removal, disinfection, softening, CECs, and salinity removal. Not always effective for taste and odor issues.	$8-10

UV – Ultraviolet
GAC – Granular Activated Carbon

Drinking Water Source Analysis



HUC4 Basin	Drinking Water Lakes	Drinking Water Rivers
Upper Mississippi-Salt	9	11
Upper Mississippi-Kaskaskia-Meramec	0	6
Missouri-Nishnabotna	4	7
Chariton-Grand	25	13
Gasconade-Osage	10	5
Lower Missouri	7	3
Upper White	0	3
Neosho-Verdigris	1	1
Lower Mississippi-St. Francis	3	2

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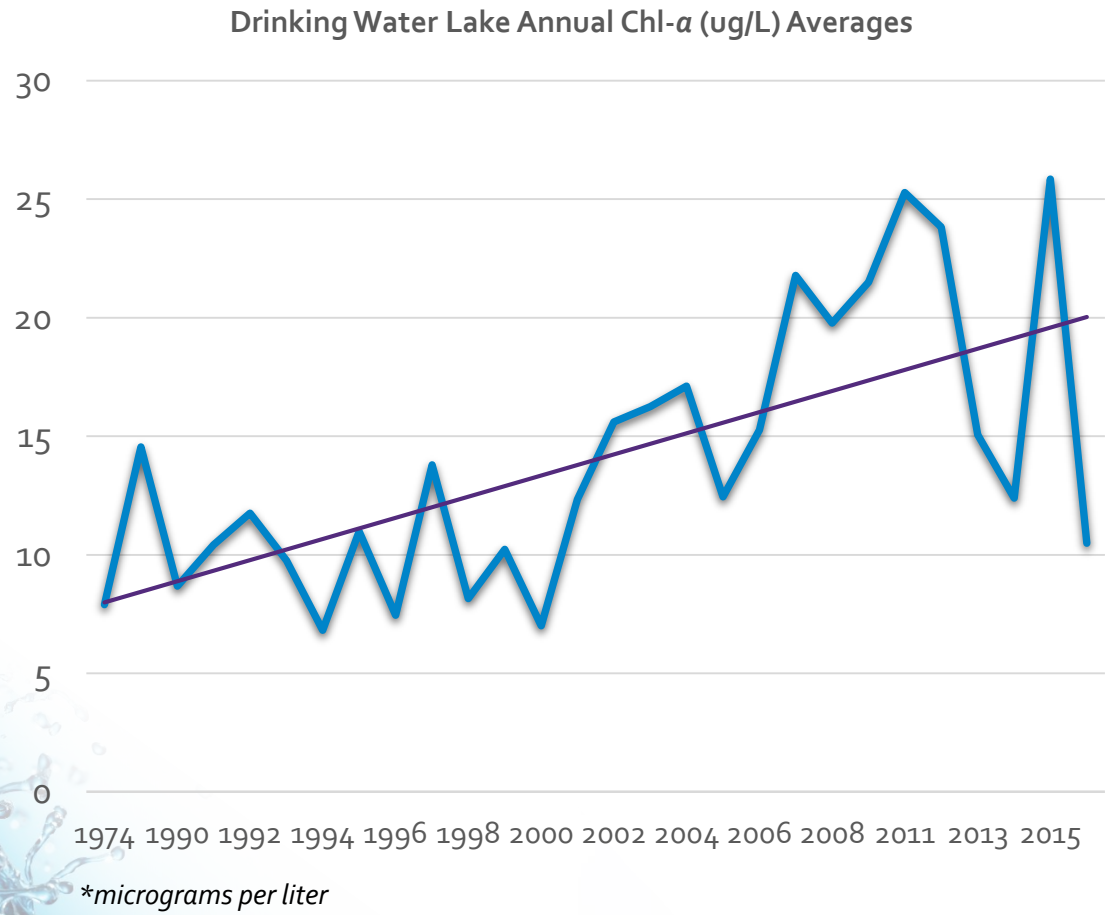
Drinking Water Sources Temporal Trend Analysis



*micrograms per liter

Lake Name	Number Samples
Garden City Lake	12
Adrian Reservoir	12
Fellows Lake	165
Stockton Lake	179
North Lake	44
McDaniel Lake	212
Harrisonville City Lake	12
Truman Reservoir	0
Butler Lake	16

MISSOURI WATER RESOURCES PLAN

Water Quality Technical Workgroup Feedback

- Narrowed the focus to source water quality impacts to drinking water
- Identified additional parameters of concern
- Identified additional data sources
- Recognized drivers of variability in 303(d) listing
- Would definitely like to see potential WQ impacts by reservoir in order to provide relevant information for planners

Questions & Discussion

Next Interagency Task Force Meeting

November 29, 2018

9:00 a.m. to 12:00 p.m.

Lewis and Clark State Office Building, Jefferson City

MISSOURI WATER RESOURCES PLAN